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Summary Report for the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) Site Visitation Program for the Period October 1987 through September 1988

Research Triangle Inst., Research Triangle Park, NC

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SUMMARY REPORT

FOR

THE NATIONAL ATMOSPHERIC DEPOSITION PROGRAM/ NATIONAL TRENDS NETWORK (NADP/NTN) SITE VISITATION PROGRAM

For the Period October 1987 through September 1988

by

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16. ABSTRACT

The U.S. Environmental Protection Agency (EPA) provides technical assistance to the NADP/NTN network through a site visitation program. Research Triangle Institute, as contractor to EPA, conducts these visits. If deficiencies or nonstandard procedures are noted, the site operator and supervisor are notified. Brief reports are sent to the EPA Project Officer, the NADP/NTN Quality Assurance Manager, and others. In this way, necessary changes can be made promptly. All NADP/NTN sites were visited in 1985-1986. A second round of visits began in October 1986, with the goal of visiting approximately one-third of the 200 sites each year over the next three years. This document is a summary report of the findings from the 1987-1988 (Fiscal Year 1988) site visitation program to 57 of the sites of the NADP/NTN network. In its present configuration, the network's research and monitoring programs are supported and operated by the U.S. Geological Survey; State Agricultural Experiment Stations; the Departments of Agriculture, the Interior, Commerce, and Energy; and EPA. Additional support is provided by state agencies, public utilities, and industries.

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ABSTRACT

The proper collection of precipitation and the accurate measurement of its constituents are important steps in attaining a better understanding of the distribution and effects of "acid rain" in the United States. One of NAPAP Task Group IV's major programs concerns wet deposition monitoring. One of that program's projects, 4A-15, "Quality Assurance Support for Wet Deposition Monitoring," is sponsored by the U.S. Environmental Protection Agency (EPA) to evaluate the sample collection process and provide technical assistance to the NADP/NTN network through a site visitation program. Research Triangle Institute, as contractor to EPA, conducts these visits. If deficiencies or nonstandard procedures are noted, the site operator and supervisor are notified. Brief reports are sent to the EPA Project Officer, the NADP/NTN Quality Assurance Manager, and others. In this way, necessary changes can be made promptly.

All NADP/NTN sites were visited in 1985-1986. A second round of visits began in October 1986, with the goal of visiting approximately one-third of the 200 sites each year over the next three years. This document is a summary report of the findings from the 1987-1988 (Fiscal Year 1988) site visitation program to 57 of the sites of the NADP/NTN network. In its present configuration, the network's research and monitoring programs are supported and operated by the U.S. Geological Survey; State Agricultural Experiment Stations; the Departments of Agriculture, the Interior, Commerce, and Energy; and EPA. Additional support is provided by state agencies, public utilities, and industries.

Protocols and procedures followed in conducting the site visits are described. Results of systems and performance audits are discussed for siting, collection equipment, and the field support laboratories. Where exceptions are found, the potential effects of nonstandard siting, improperly operating equipment, and improper sample handling or analysis technique on the data base are discussed.

This report was submitted in partial fulfillment of EPA Contract No. 68-D8-0001 by Research Triangle Institute. This report covers site visits made during the period October 1, 1987, through September 30, 1988. All work was completed as of September 30, 1988.

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SECTION 1
INTRODUCTION

This document is the summarizing report of quality assurance assistance and findings from site visits made to the National Atmospheric Deposition Program/ National Trends Network (NADP/NTN) precipitation collection stations in the period October 1987 through September 1988. Each site is located and operated according to protocols and procedures as given in the siting and operating manuals for the networks (1, 2, 3, and 4). The purposes of the site visitation program, sponsored by the U.S. Environmental Protection Agency (EPA), are to verify that each site is operating within control limits and according to established procedures, and to provide technical assistance as required.

Fifty-seven of the 196 sites that were in operation as of January 15, 1989, were visited during this time frame. Table 1 lists the sites by name, their identification numbers, the names of each site's supervisor and operator, and the date of the site visit. Figure 1 shows the NADP/NTN site locations.

GOALS

The goals of the site visitation program for quality assurance assistance to the NADP/NTN collection sites are as follows:

(1) Provide a qualitative assessment of each site and its surroundings, the operator's adherence to sample collection and analysis procedures, and the condition of the site's collection and analysis equipment through an on-site systems survey;

(2) Provide a quantitative assessment of the operation of the precipitation collector and the accuracy of response of field and laboratory measurement devices for precipitation depth, mass, temperature, conductivity, and pH through an on-site performance survey;

(3) Provide technical assistance to the operator by verbal explanation, minor troubleshooting, repair and calibration of equipment, and by making recommendations for sources of corrective action;

TABLE 1. NADP SITES VISITED IN FY 1988

Site Name (101)	ID	Supervisor (102)	Operator (103)	Date of Site Visit (108)
Black Belt Substation	011000	Ira Giles	Harold Grimes	05/24/88
Denali	020390	John Dalle-Molle	Joann Unruh	07/21/88
Oliver Knoll	030360	Del Moliter	Diane Drobka	01/21/88
Grand Canyon	030370	Rick Ernenwyn	Renee Beymer	05/03/88
Organ Pipe Cactus	030620	Bill Mikus	Roy Irving	01/22/88
Tanbark Flats	054200	Paul Martin	Charles Colver	02/01/88
Hopland	054540	Dan Brown	Milton Jones	02/19/88
Sequoia NP-Giant For	057550	David Parson	Annie Esp	02/03/88
Montague	057680	Mike Friebel	Ken Corbin	02/16/88
Chuchupate	058501	Keith Polinoski	Gail Conklin	02/02/88
Davis	058840	Paul Martin	Paul Martin	02/17/88
Yosemite NP	058850	Carol Moses	Antonina Hines	02/23/88
Mesa Verde NP	061530	Bob Heyder	Marilyn Colyer	05/04/88
Craters of the Moon	130343	Karl Gephart	Neil King	04/13/88
Smiths Ferry	131500	Victor Kollack	Mary Samuelson	04/18/88
Perryville Battle.	180360	Kevin M. Butt	Kevin McGill	08/10/88
Wye	211320	Russ Brinsfield	Mike Newell	08/17/88
Douglas Lake	230920	Dan Richter	Robert Kopple	05/26/88
Raco	230980	Darrel DeRouin	Karen Waalen	05/25/88
Kellogg Bio. Stn.	232660	Dr. James Hart	Steve Lachance	05/23/88
Wellston	235340	Elon Verry	William Dunn	05/24/88
Newton	251960	Richard Artz	Ted Wilson	11/03/87
Custer Battle. NM	270060	Clifford Arlagast	Mike Smith	07/25/88
Glacier NP Fire WS	270570	Dave Lange	Tom Pittinger	07/29/88
Havre Exp. Stn.	270740	Roger Knapton	Al Horsley	08/01/88
Clancy	270760	Roger Knapton	Kent Dodge	08/02/88
Give Out Morgan	271340	Fred Steele	Fred Steele	07/21/88
Red Rock Canyon	290080	David Schafersman	Joel Muir	02/04/88
Saval Ranch	290140	Donn Siebert	Donn Siebert	04/12/88
Smith Valley	290360	Richard LaCamera	Alan Preissler	02/22/88
Lehman Caves NM	290560	Bill Wagner	Norm Hiestand	04/11/88
Gila Cliff Dwellings	320180	Karl Peyton	Donnie Forman	04/27/88
Bandelier NM	320720	Craig Eberhart	Michael Trujillo	04/28/88
Mayhill	320840	Bernie Chavez	Calvin Morris	01/25/88
Cuba	320980	Bernie Chavez	David Bodine	04/29/88

(continued)

TABLE 1 (cont). NADP SITES VISITED IN FY 1988

Site Name (101)	ID	Supervisor (102)	Operator (103)	Date of Site Visit (108)
Capulin Mountain NM	321280	Ed Peyton	George R. West	04/25/88
Piedmont Res. Stn.	343460	Dr. Bruck/C. Sasser	Billy Ascue	04/28/88
Clinton Crops RS	343560	Dr. Bruck	Fred E. Cumbo	04/26/88
Jordan Creek	343600	Kent Crawford	Avery J. Dennis	05/17/88
Finley Farm	344160	A. S. Heagle	Judy Elson	12/17/87
Salt Plains NWR	370060	Lealand Hauth	Philip Garcia	03/16/88
Great Plains Ap.	371740	John Carter	Kin Mang Hwa	03/15/88
Goodwell Res. Stn.	372920	Richard Artz	Eugene Reeves	04/26/88
Muleshoe NWR	450250	Don Clapp	Dean Gilliam	03/18/88
Big Bend NP - K-Bar	450425	Mike Flemming	Raymond Skiles	01/27/88
Sonora	451650	Charles Taylor	Nick Garza	03/21/88
Guadalupe Mtns NP	452215	Chief Ranger	O. V. Olsen	01/26/88
Throckmorton	455180	Rod Heitschmidt	Steve Dowhower	03/22/88
LBJ Natl. Grasslands	455640	Bill Herb	Clyde Schoultz	03/23/88
Bryce Canyon NP	460110	Robert Keene	Linda Kerr	05/02/88
Logan	460120	R. Artz	Zane Stephens	04/19/88
Murphy Ridge	460820	Reid Smith	Lee Bodine	04/14/88
Olympic NP Hoh RS	491410	John Aho	Janet Kailin	07/19/88
Cascades NP Marble.	491940	Dave Brakke	Jeannie Harsha	07/18/88
LaGrande	492180	^	Paul Ringold	07/20/88
Palouse Cons. Farm	492420	Gary Turney	Robert Pust	07/13/88
Yellowstone NP TF	520860	Craig McClure	Randy King	07/26/88

^ = not checked.

Figure 1. Locations of active sites in the NADP/NTN network as of 15 August 1989

(4) Prepare brief reports for each site detailing site characteristics, results of quality assurance tests, and technical assistance provided. Submit the reports to the NADP/NTN Quality Assurance Manager, the Central Analytical Laboratory's Site Liaison, and the EPA Project Officer;

(5) Computerize results of all information gathered from each site and submit this to the NADP/NTN Quality Assurance Manager on an annual basis;

(6) Document the sites and their surroundings by assembling a collection of site maps and color photographs.

This report is divided into eight sections:

Section	Topic
1	Introduction
2	Conclusions
3	Recommendations
4	Approach
5	Protocols and Procedures for Collection Site Visits
6	Site and Field Laboratory Surveys: Results and Discussion - Siting Survey - Equipment and Sample Collection Survey - Field Laboratory Survey
7	Comparison of 1988 and 1985-1986 Site Visitation Results
8	References

SECTION 2
CONCLUSIONS

Fifty-seven of the 196 active NADP/NTN precipitation collection sites were visited over the one-year period, October 1987 through September 1988. About one-third of the sites were visited during this second year of a three-year effort. The sites are located in all regions of the country and are sponsored and operated by numerous agencies. Each site is located according to established siting criteria and operates according to published procedures. This report assesses the degree to which criteria and procedures are adhered to; predicts, where possible, the relative impact on the data which might be expected from the variances found; and compares results thus far from the second round of visits to those documented in the first round of visits that occurred over the period December 1984 through September 1986.

SITING

Improvements in adherence to siting criteria were noted at most of the sites visited in 1988 which were not in compliance at the time of the first round of visits in 1985-1986. A number of sites had separated the collector and rain gauge to the prescribed 5-m distance and had oriented the collector's wet-side bucket to the west. Obstructions and sources of dust such as animals, parking lots, and chemical storage areas had been removed, or the site's equipment had been moved away from them.

For the 13 siting criteria summarized in this report (refer to Table 4), 41 of 57 sites (72%) visited in FY 1988 had at least one variance. Twenty-five percent of the sites had three or more variances. However, most of the variances are expected to have minimal effects on the data base because of the nature of certain criteria and/or the degree to which the criteria were exceeded. For example, network siting criteria require that the precipitation collector and rain gauge be separated by at least 5 m but no more than 30 m. Twenty-six percent of the 57 sites did not meet this criterion, always because of inadequate separation. It is not likely that the effect is measurable in the

precipitation chemistry or catch efficiency as compared to a site that meets the criterion. Variances concerning collector height, wet bucket orientation, ground slope, collector-gauge separation, collector-gauge heights, and vegetation higher than 2 ft account for many of the instances and probably have little effect on the data.

The remainder of the variances are due to the presence of obstructions or potential pollutant sources near the sites. For instance, 5 of 57 sites had obstructions near the collector that violated the 45° rule (the top of the obstruction should not extend beyond a 45° arc as measured from the collector). Three sites had storage or lots within 100 m of the collector, at 12 sites animals were allowed to move closer than 30 m to the collector, and 2 sites had transportation sources within 100 m of the collector.

Variances due to obstructions or pollutant sources may have measurable effects on the data; but because the type, magnitude, and proximity of the obstructions and sources vary widely from site to site, a measure of the effects is not possible from the data gathered in the site visitation program.

SAMPLE COLLECTION

Designated sample collection procedures were adhered to at almost all the sites in the network. All operators were careful not to touch the inside of the collection bucket or lid or contaminate the sample in any way. All site operators stated that they checked the sample for contaminants (leaves, bird droppings, etc.) at the time of the bucket's removal from the collector. This procedure was not being well adhered to at the time of the first round of visits.

To ensure accurate precipitation data, it is most important that the precipitation collector and rain gauge are properly working and well-maintained. Only two sites were unable to make a weekly equipment check. A properly working precipitation collector should uncover the wet bucket at the beginning of a precipitation event and recover the wet bucket shortly after the event stops to keep matter such as dust out of the wet bucket when there is no precipitation. There were indications at 13 of 57 sites (23% of the total) that the clutch on the Aerochem Metrics precipitation collector was wearing; however, only 2 of these 13 failed to operate properly when tested with a 1600-g load. Only 2 of 55 sensors checked were not operating properly. Fifty-two percent of the rain

gauges (29 of 56) were found to be out of calibration by more than ± 0.1 in. at some point on the 0-12-in. scale. This is not believed to be a major source of error because the calibration errors usually occurred at a depth of 5 in. or more, and the operator is instructed to empty the catch bucket before this depth is reached. Calibration checks showed that 48 of the 56 gauges (86%) met acceptable calibration criteria (± 0.1 in.) over the range of 0 to 5 in.

FIELD LABORATORY PROCEDURES

Field laboratory procedures for sample handling, conductivity measurements, and pH determinations were being carried out properly and accurately in almost all cases. Proper procedures were discussed or demonstrated to site operators as needed.

Results were improved over those noted at the time of the first round of visits. For example, all but three sites were able to determine the pH to within ± 0.1 unit of the designated value. Two sites had inoperative pH meters and could not be checked. All six of the sites that were outside of tolerance for pH measurements in Round 1 were within tolerance in Round 2. Overall, 95% of the 55 field laboratories checked in 1988 agreed within ± 0.1 pH unit with the audit solution's designated value.

For conductivity measurements, each of the 53 sites checked (100%) determined the audit solution's conductivity to within ± 4 μS/cm of the designated value. Four sites had exceeded the limit of agreement during Round 1 visits. Four sites had malfunctioning or broken equipment and thus could not be audited.

The solution balances were operating properly in all of the 56 cases checked. Of 56 balances checked, more than half agreed within ± 1 g with the designated weight over the range of 823 to 4043 g. All but one balance agreed within ± 5 g with the designated weight over the same range. In terms of percent variation with respect to weight, the worst case for the 55 balances that operated within ± 5 g agreement would be ± 0.6% at a loading of 823 g and ± 0.1% at a loading of 4043 g.

SECTION 3
RECOMMENDATIONS

The site precipitation collector and rain gauge are central to the successful operation of the network. However, the equipment in the NADP/NTN network is aging and will require increased maintenance. Therefore, weekly equipment checks by the operator should continue to detect problems as early as possible. The collector's clutch assembly should be inspected for signs of wear. The failure of the precipitation collector's sensor heaters has greatly diminished. A simple check of the collector's sensor heater by activating the collector with water and, after 5 min, lightly touching the sensor surface to verify it is heating, should continue.

A number of rain gauges were found to be out of calibration. However, many of those calibrated in 1985-1986 met specifications in 1988. It is recommended that a simple, on-site calibration check of the rain gauge be carried out every six months. A copy of the gauge chart used for the check should be forwarded to the network's Central Analytical Laboratory (CAL) for review.

Recommendations for improving site locations center around those siting criteria that, if violated, may affect the catch efficiency or chemistry of the precipitation samples. Specifically, it is recommended that the NADP/NTN Coordination Office take the following steps to correct conditions at several sites.

- Relocate the collector or remove the obstruction (tree, etc.) that causes the 45° angle rule to be violated (five sites).
- Relocate the collector or restrict use of nearby parking lots and storage facilities so that a 100-m separation is achieved (six sites).
- Relocate the collector or install fencing so that animals are kept at least 30 m away (12 sites).
- Relocate the collector so that transportation roadways and sources are at least 100 m away (two sites).
- Reorient the collectors whose wet-side collection bucket faces North or East so that all wet-side buckets face West (seven sites).

- Where expedient and inexpensive to do so, relocate collectors or rain gauges so that a minimum separation distance of 5 m is achieved (15 sites).

- Emphasize to site operators and supervisors that grass, weeds, and small trees or bushes should be kept at a height of 2 ft. or less in a circle with a radius of 30 m from the collector.

- Level any collectors or rain gauges that are out of tolerance (two sites).

- Investigate whether or not the resistivity required to activate the collector sensor should be set closer to the factory value of 80K Ω for several of the collectors.

- Supply rain gauge dampening fluid (silicone oil) to those sites that may need to fill reservoirs to within 0.25 in. of the top.

The quality assurance information provided by these site visits is only a portion of the total available. It represents only a "snapshot" of the total monitoring period. The site visit information may be merged with other site and CAL-acquired information to allow a more comprehensive evaluation of the effect of variations on the total data base. For instance, if the site visit revealed that the collector's sensor was not heating, other sources of information may be used to deduce over what period it was malfunctioning (e.g., a careful examination of the opening/closing cycles as shown on the recording rain gauge chart; review of site logbook to note repair data).

SECTION 4
APPROACH

A five-step approach was utilized in preparing for and conducting visits to precipitation collection sites in the NADP/NTN network.

SITE VISITOR TRAINING SESSIONS

Four of the five Research Triangle Institute (RTI) site visitors participated in a formal instructional course for NADP/NTN site operators. These courses are held at the network's Central Analytical Laboratory, Illinois State Water Survey, in Champaign. These training sessions gave site visitation team members the opportunity to meet site operators in advance of the visits and to learn what is expected of a site operator. The fifth visitor was instructed by those who had attended the instructional course.

DOCUMENT REVIEW AND REVISION OF THE SITE VISITATION QUESTIONNAIRE

The latest network documents (1, 2, and 3) were reviewed, and on the basis of their contents, the site visitation work plan and questionnaires (4) were revised. The questionnaires are used to conduct systems and performance surveys of the site and field laboratory operations and to assess the operator's adherence to designated procedures. Information on the sites and requests for supplementary information were also received from the Site Liaisons at the Central Analytical Laboratory and the Coordination Office.

CONTACT WITH SITE PERSONNEL

In coordination with the EPA Project Officer, contact was made by telephone and letter with those persons whose sites were to be visited. Both the site supervisor and operator were encouraged to be present. The dates for the site visits were set, the itinerary was planned, and information such as topographical maps was acquired and studied prior to the actual site visit.

EVALUATION OF AND TECHNICAL ASSISTANCE AT SITES

The sites and field laboratories were visited and evaluated. During the visit, the questionnaires were completed, and each site was documented by sketch and photographs. The site's location was verified on a U.S. Geological Survey (USGS) 1:24,000 series map. Supplemental information requested by the Coordination Office was obtained.

The second round of site visits began in October 1986 and is to continue through September 1989. In this second year (1987-1988) of the second round of visits, 57 of 196 active sites were visited.

REPORTING OF RESULTS

Five types of reports were prepared in the site visitation program. They are:

- Brief handwritten exit reports that are left at the site;
- Longer handwritten reports that are prepared, upon return from the field;
- Annual reports to the NADP at the time of the annual technical review session;
- Computerized tapes and printouts containing all answers and comments recorded in the site visitation notebooks; and
- This annual summary report that is distributed by EPA.

Throughout the site visit, the site visitor verbally briefed the supervisor and operator on the results of the systems and performance survey. At the conclusion of the visit, a handwritten exit report was prepared, and a copy was provided to them. Copies of the brief and longer reports of the survey results (including recommendations for corrective action) were mailed to the site liaisons at CAL and to the NADP/NTN Quality Assurance Manager at the Coordination Office. Figure 2 illustrates the categories covered in the brief report.

Bound copies of the original notebooks containing the site survey results are kept on file at RTI. Copies of the notebooks, the photographs, and annotated maps are sent to the QA Manager's Office for study and archiving.

NADP/NTN SITE VISITATION PROGRAM
Brief Site Survey Report Form

RTI Proj. _____

2/89 (Rev. 1)

A. Site Information

(101) 1. Site Name _____
(101) 2. CAL Code _____
3. CSU Code _____
(102) 4. Supervisor's Name _____
(103) 5. Operator's Name _____
(106) 6. Operator address incorrect.
(108) 7. Date of visit _____ (m) _____ (d) _____ (y)
(113) 8. RTI Visitor's Name _____
9. RTI Notebook Number _____
10. Site location changed since last visit.
(104) 11. Regular operator not present.
12. Site supervisor not present.
(101A) 13. Site sponsor _____
14. Other.

B. Siting Criteria

(209) 15. Collector on platform.
(215) 16. Wet bucket not west; sensor not north.
(122,124) 17. Ground cover, slope, or buffer zone.
(214) 18. Collector base is enclosed.
(127) 19. Objects >1 m high within 5 m.
(236,237) 20. Collector/gauge separation or height nonstandard.
(224-229) 21. Snow roof.
(123) 22. Vegetation higher than 2 feet.
(128) 23. 45° rule violated.
(129) 24. Storage or lots <100 m distant.
(126,131) 25. Animals or pasture <20 m. Feedlots <500 m.
(130) 26. Transportation sources <100 m.
(127) 27. Residential buildings outside 30° cone.
(132) 28. Industry <10 km distant (<20 km if upwind).
(134) 29. Site is urban influenced.
30. Other.

C. Equipment Summary

Aerochem Metrics Collector

(234,256) 44. Clutch tooth or collar worn.
(243) 47. Lid seal to wet bucket has gaps.
(251) 51. Sensor does not heat when activated.
58. Other.

(Table A-1) **Belfort Rain Gauge**

(350-354) 69. Gauge calibration out >0.1" (0 to 5")
(355,356) 70. Crossover point off >0.1".
(355-361) 71. Gauge calibration out >0.1" (6 to 12")
76. Other.

D. Sample Collection Procedures

(401-408) 78. Incomplete sampler servicing.
(410) 79. Sensor heater not checked each visit.
82. Other.

E. Field Laboratory Summary

Audit Test Solution No. _____

Conductivity Measurements

(703) 90. DI water > 10 µS/cm _____.
(704) 91. Check sample beyond 21.8 ± 3 µS/cm _____.
(705) 92. Site value, audit, _____ µS/cm.
(705) 93. Designated value, audit, _____ µS/cm.

pH Measurements

(603) 99. Check sample outside 4.30 ± 0.1 _____.
(604) 100. Site value, audit, _____ pH units.
(604) 101. Designated value, audit, _____ pH units.
103. Other.

F. Notes and Comments

Entry No.

_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____
_____ _____

Figure 2. Form for Brief Report of Site Visits.

An annual report, consisting of a technical summary of the year's activities, was presented in a briefing to NADP/NTN at the time of the annual technical meeting. A poster session was presented at the October 1988 meeting in Champaign, IL.

Still another report is a computerized file of all questions, answers, and comments from each of the site visitation program notebooks. These validated files are submitted to the Coordination Office at Colorado State University via electronic transfer. Selected information from these files is compiled in the tables and graphs of this annual summary report.

SECTION 5
PROTOCOLS AND PROCEDURES FOR COLLECTION SITE VISITS

SCHEDULING

For this second round, each NADP/NTN site was to be visited once in a three-year period. About one-third of the 196 active sites were visited in the second year (1987-1988). Prior to the scheduling of site visits, RTI consulted with the NADP/NTN QA Manager and CAL site liaison to determine if any sites should be seen on a priority basis. Visits were planned so that several sites in the same vicinity could be seen in the same trip.

The following sequence was followed when arranging a visit to a collection sites.

- About two months before the anticipated date of visit, RTI selects a set of sites in a location suitable for a trip lasting up to two weeks and sets a tentative schedule for visits. As many as eight sites may be visited in this time frame, according to the proximity of the sites.

- The NADP/NTN QA Manager, the Central Analytical Laboratory of the Illinois State Water Survey, and the sponsoring agency are notified by letter of the proposed visits. CAL and the Coordination Office supply pertinent information concerning each site.

- Each site's supervisor is telephoned to set up the visit. The site supervisor, may contact the operator or request that RTI contact the operator to confirm the date, time, and place of the visit. When the supervisor makes the arrangement, he contacts RTI prior to the planned visit to confirm or alter the initial plan.

- A form letter is sent to each site's supervisor and operator that confirms the date, time, and place of the visit. This letter also gives a brief agenda for the visit and an estimate of the time to set aside for the visit (usually 4 to 5h).

A flow chart of the activities carried out in preparation for, conduct of, and reporting of a site visit is given in Figure 3.

FLOW CHART FOR SITE VISITS

I. SELECT SITE FOR VISIT AND INITIAL COMMUNICATIONS

- Advise QA Manager, CAL, site sponsor of plans; request site information; receive go-ahead
- Contact site supervisor, site operator, sponsoring agency
- Send letter of confirmation to supervisor, operator, agency
- Advise EPA that trip plans are complete

II. PRE-TRIP PREPARATION

- Make travel arrangements (air, car, hotel)
- Prepare and test quality assurance materials
- Review site-specific quality control information (maps, QC test results, etc.)
- Check equipment and supplies
- Prepare site visit notebook

III. CONDUCT SITE VISIT

- Outline activities to supervisor and operator
- Assess site and surroundings (map, photographs, obstructions, sources)
- QA tests of precipitation collector and gauge
- Adjust or calibrate collection equipment as required
- Assess operator handling and transport of collection bucket
- QA tests of conductivity and pH meters, balance
- Examination of site records, rain gauge charts
- Answer questions; provide information
- Prepare brief report; conduct exit interview

IV. REPORTING

- Brief report prepared; left with supervisor or operator
- Copy of brief and extended reports forwarded to NADP/NTN QA Manager, to CAL, and to EPA Project Officer
- Copy of site visit notebook sent to NADP/NTN QA Manager; file original
- Summary reports prepared monthly and annually
- Report presented to NADP/NTN committees twice annually

Figure 3. Flow Chart for Site Visits.

PRE-TRIP PREPARATION

Prior to each trip to a set of collection sites, the following preparations were made: travel arrangements, preparation and testing of quality assurance equipment and materials, review of site-specific quality control information, packaging and double-check of all equipment and supplies, preparation of site survey notebooks.

Review of Site-Specific Quality Control Information

Information on individual collection sites was supplied to RTI by the NADP/NTN Coordination Office's site liaison and the CAL site liaison in advance of the survey trips so that site contacts could be established and special attention given to an individual site's needs. This information, supplied in the written form and through telephone conversations contained the following.

- The site supervisor's and operator's names, addresses, and telephone numbers
- A description of the site and surroundings
- A list of the equipment at the site
- Confidential information on the operator's performance
- The site description questionnaire
- Requests for supplemental information to help answer unresolved questions

The above, along with information obtained during earlier site visits, was reviewed at RTI prior to visiting the collection site. Confidential information was not discussed with the site operator.

Preparation of Site Survey Notebooks

Notebooks were prepared for use at each site. Each set of notebooks contained information concerning the site (operator, location, etc.), a record of pre-trip confirmation of test solutions, balance weights, etc., and the site survey questionnaire. Each notebook was bound, numbered, and checked for accuracy before the site visit. Upon completion and review, the original notebook

was filed at RTI by using a document control system. A copy of the notebook was provided to the NADP/NTN Coordination Office.

SITE SURVEY VISITS

RTI personnel (W.C. Eaton, C.E. Moore, R.W. Murdoch, R.C. Shores, or D.A. Ward) accompanied the site personnel to each collection site and field laboratory with the aims of (1) documenting the site and its immediate surroundings, its operation, and the accuracy of its instruments' responses to various quality assurance tests and (2) providing information, training, and instruction for operators and supervisors; equipment calibration and minor maintenance as needed; and establishing contacts for further information or major repairs. A general list of items checked is given in Table 2.

Systems Survey

A quality assurance systems survey was conducted at each site to qualitatively assess the site, its surroundings, and the operator's adherence to procedures specified in the NTN design document (1) and in the NADP/NTN site operator's instruction manual (3). Criteria for siting an NADP/NTN precipitation station are illustrated in Figure 4. The operator was asked to demonstrate sample collection and analysis procedures. These were observed with special attention given to calibration procedures and sample handling technique. Site equipment was examined for signs of wear or faulty operation. It was noted whether solutions and equipment were properly stored. Site logbooks and rain gauge charts (if present) were examined for legibility, completeness, and accuracy.

Information from the systems survey was entered in the systems survey questionnaire. Two sets of photographs (color slides) of the sites were taken. The N, E, S, and W views were photographed with the precipitation collector in the foreground. Additional views were taken as specified in the questionnaire.

Performance Survey

A quantitative performance survey was conducted at each site. Table 3 lists the equipment that was checked for performance and the type of test used. Criteria for evaluating performance are specified in the NADP Quality Assurance

TABLE 2. LIST OF ITEMS CHECKED DURING SITE SURVEY VISIT

Precipitation Sampler

- lid/bucket seal
- absence of gaps
- sensor heater operation
- clutch tension
- clutch wear
- winter problems
- proper counterbalance
- contamination by straps, wires
- snow roof design, material, orientation
- levelness and stability
- lid tension or drop
- bucket/sample handling
- orientation, height
- distance from other equipment

Supplies

- check inventory
- shortage of buckets
- excess buckets

Mass

- accuracy of response
- calibration weight handling
- tolerance checks
- correct use of balance

Precipitation Gauge

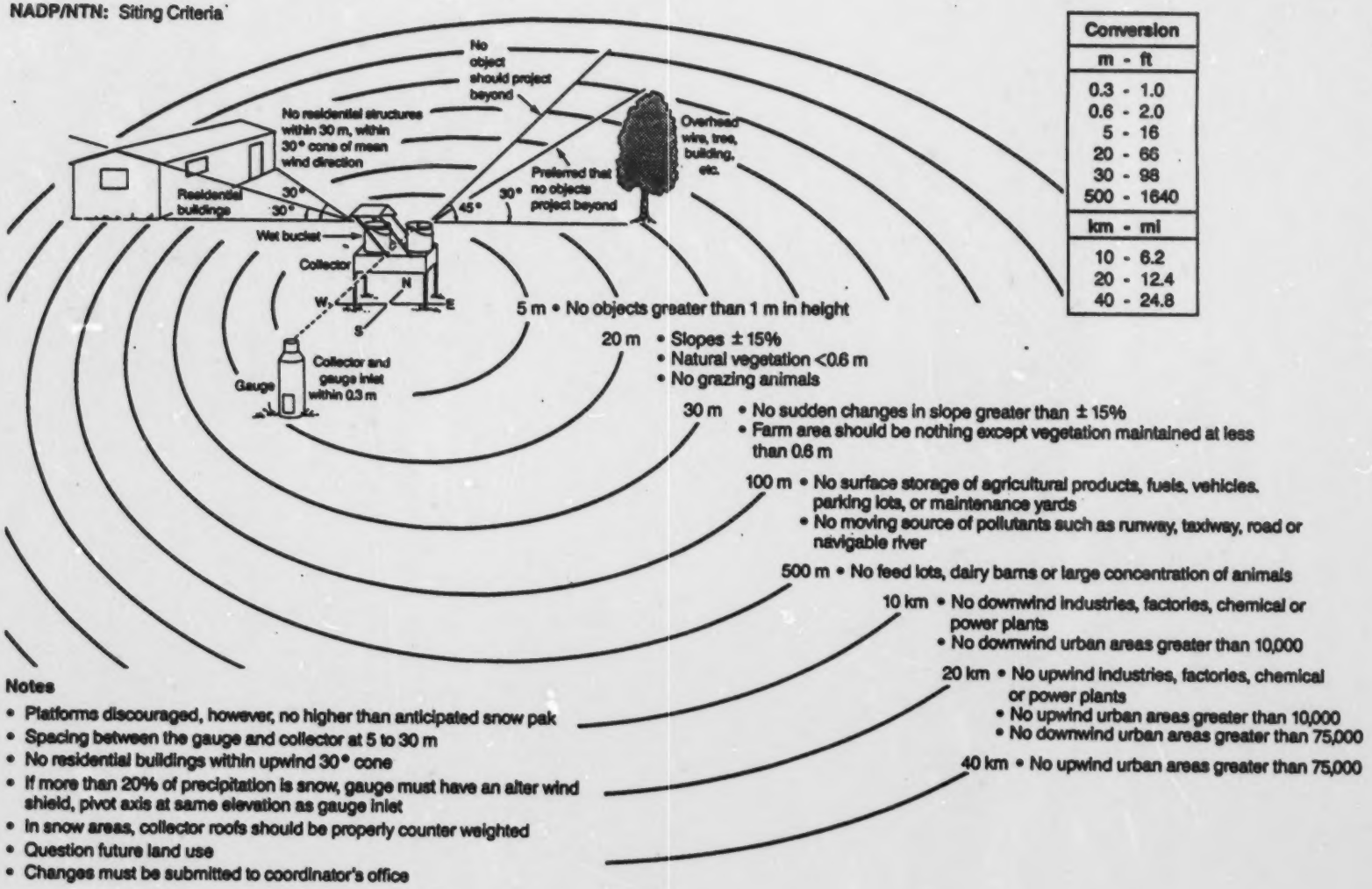
- winterization
- accuracy of calibration (weight response)
- sensitivity (response to small weights, 0.1 in.)
- cleanliness
- time calibration
- event marker operation
- ability to read chart correctly
- distance from other equipment
- height
- levelness and stability

pH Meter and Use

- accuracy of response
- no electrodes in bucket
- $\pm$ 0.1 pH unit agreement with test solution
- electrode condition
- electrode brand
- order of use
- use of pH check solution
- storage of buffers, check solutions

Conductivity

- accuracy of response
- no electrode in bucket
- use of standards


NADP/NTN: Siting Criteria
No object should project beyond
No residential structures within 30 m, within 30° cone of mean wind direction
Overhead wire, tree, building, etc.
Preferred that no objects project beyond
Residential buildings
30°
30°
45°
30°
Wet bucket
Collector
N
W
E
S
Gauge
Collector and gauge inlet within 0.3 m
5 m • No objects greater than 1 m in height
20 m • Slopes ± 15%
• Natural vegetation <0.6 m
• No grazing animals
30 m • No sudden changes in slope greater than ± 15%
• Farm area should be nothing except vegetation maintained at less than 0.6 m
100 m • No surface storage of agricultural products, fuels, vehicles, parking lots, or maintenance yards
• No moving source of pollutants such as runway, taxiway, road or navigable river
500 m • No feed lots, dairy barns or large concentration of animals
10 km • No downwind industries, factories, chemical or power plants
• No downwind urban areas greater than 10,000
20 km • No upwind industries, factories, chemical or power plants
• No upwind urban areas greater than 10,000
• No downwind urban areas greater than 75,000
40 km • No upwind urban areas greater than 75,000
Notes
• Platforms discouraged, however, no higher than anticipated snow pak
• Spacing between the gauge and collector at 5 to 30 m
• No residential buildings within upwind 30° cone
• If more than 20% of precipitation is snow, gauge must have an alter wind shield, pivot axis at same elevation as gauge inlet
• In snow areas, collector roofs should be properly counter weighted
• Question future land use
• Changes must be submitted to coordinator's office

Conversion
m - ft
0.3 - 1.0
0.6 - 2.0
5 - 16
20 - 66
30 - 98
500 - 1640
km - mi
10 - 6.2
20 - 12.4
40 - 24.8

Figure 4. NADP/NTN Siting Criteria Diagram

TABLE 3. NADP/NTN SITE MEASUREMENTS AND PERFORMANCE SURVEY METHODS

Site Measurement	Measurement Device	Performance Survey Method	Designated Performance Criteria
Rain depth	Rain gauge (Belfort)	Challenge with known weights that simulate rainfall.	Agreement within ± 0.1 in. of test weight value over the range 0-12 in.
Precipitation sample collection	Precipitation collector (Aerochem Metrics)	Measure resistance across sensor, measure tension and drop of bucket lid, measure temperature and resistance of activated sensor.	Resistance in range of 60-90 KΩ. Lid drop distance > 3 mm. Sensor temperature ambient prior to activation; temperature of 50-70°C after activation.
Mass	Triple beam balance	Challenge with traceable weights.	Agreement within ± 5 g of test weight value.
pH	pH meter and electrode	Challenge with simulated precipitation sample of known pH.	Agreement within ± 0.1 pH unit of test solution's designated value.
Conductivity	Conductivity meter and cell	Challenge with simulated precipitation sample of known conductivity.	Agreement within ± 4 µS/cm of test solution's designated value.

Plan (1). All information was recorded in the performance survey questionnaire. Several items having to do with quality assurance test equipment, materials, andprocedures are discussed below.

Precipitation Depth--

The calibration of the Belfort recording rain gauge was checked over the range 0 to 12 in. by use of the certified weight set (Number 8849 6P-1) obtained from Belfort Instrument Company. The accuracy of the weight set was verified by periodically reweighing the weights versus NIST- or International Organization for Legal Metrology (IOLM)-traceable standards. To conduct the test, the operator removed the chart from the gauge and replaced it with a new one. Proper alignment of the chart on the drum was verified by the operator and the site visitor. Next, the zero reading was established, and then a series of weights were placed on the gauge to simulate precipitation in 1-in. increments from 1 to 12 in. (in very dry areas, only the range 0 to 6 in. may be checked). Sensitivity was checked by placing weights corresponding to 0.2 in. depth or less on the gauge. Gauge response was recorded in the notebook and on the chart.

If any one reading was more than $\pm$ 0.10 in. from the designated value, the gauge was calibrated (weather permitting) by using the procedure given in the gauge manual (5).

One agency, the National Oceanic and Atmospheric Administration (NOAA) has its own program of precipitation gauge calibrations. If a NOAA-sponsored rain gauge was found to be outside the tolerance ($\pm$ 0.10 in.), the site supervisor was notified; no calibration was performed by the site visitation team.

Precipitation Collector--

Several aspects of the Aerochem Metrics precipitation collector were checked. Information and check procedures are given in the collector's maintenance manual (6).

Mechanical -- The proper opening and closing cycle of the collector was checked by applying deionized water to the sensor and watching and timing the open-close cycle. Wear on the thrust collar indent and thrust tooth was visually checked. Clutch pressure was checked by the mechanism's ability to lift 1640 g (two Belfort calibration weights).

Tension on lid -- Lid tension was checked in two ways: (1) lifting the lid slightly with a spring scale and noting the force required and (2) measuring the distance between the collector tabletop and the bottom edge of the lid with and without the collection bucket in place and noting the difference.

Sensor -- The sensor's cleanliness, proper voltage, output to the event marker, electrical resistance at which the lid displaces, and heating (measured by a thermocouple placed against the sensor plate) were checked.

Mass--

The accuracy of mass determination of the collection bucket contents by the triple beam balance was checked by having the operator weigh several Belfort rain gauge weights which had been calibrated to $\pm$ 0.1 g against IOLM-certified brass weights.

pH and Conductivity--

The accuracies of pH and conductivity measurements were checked by having the site operator analyze a simulated precipitation sample. This sample was a dilute solution of one of the EPA/NIST simulated precipitation reference materials which have been in use as quality assurance materials for several years or a dilute, quality control sample prepared and characterized by the EPA Atmospheric Research and Exposure Assessment Laboratory (AREAL) in Research Triangle Park (RTP), NC. Some of the check samples were tested at RTI before being taken on a collection site trip. The solutions were subject to recheck upon their return from a field trip. The test sample was not placed in a collection bucket, but rather was given to the operator to add to the analysis vessels in the field laboratory.

Technical Assistance and Maintenance

Technical assistance in the form of instruction, explanation, or demonstration was provided as needed to improve site performance. This assistance often included a discussion or demonstration of proper analytical techniques, instrument use, and calibration procedures. Operator questions were answered or referred to other NADP/NTN program personnel.

Whenever an equipment deficiency was found at the site, the problem was identified, corrective action recommended (see maintenance subsection), and as necessary, the operator and supervisor were referred to CAL for additional information and guidance.

Minor maintenance was performed at NADP/NTN sites in an effort to improve site performance. The level of maintenance provided was limited by the amount of time required to complete a particular task and by the amount of equipment which could be carried to the field.

Exit Interview

At the conclusion of the site survey, a short report of the visit was written (refer to Figure 2), and the results were discussed with the site operator or supervisor or both. During the exit interview, the operator and supervisor were given the opportunity to ask additional questions and express their feeling about the NADP/NTN program and their responsibilities within it.

SECTION 6
SITE AND FIELD LABORATORY SURVEYS
RESULTS AND DISCUSSION

SITING SURVEY

A total of 57 NADP/NTN sites were surveyed in fiscal year 1988. Each site is equipped with an Aerochem Metrics precipitation collector and a Belfort rain gauge. Specific procedures outlining the operation of this equipment for the collection of weekly precipitation samples are in place (2, 5, and 6). In addition, there are written siting criteria that specify minimum requirements each site should meet with regard to equipment placement, terrain, topography, and potential pollutant sources (3). Given below are results of qualitative system assessments made at each site with respect to NADP/NTN siting criteria and operational guidelines.

Siting Criteria Survey Results

Table 4 presents the results of assessments made at each site with respect to 17 siting criteria. The results of the findings are discussed below.

Collector Installation/Location--

The collector should be installed on its standard 1-m-high aluminum base. Any of several methods can be used to stabilize or level the collector such as concrete pads or stakes. However, the bucket height of the collector should not vary from its standard height by more than $\pm$ 0.5 m. An exception to this criterion is permitted in areas with significant accumulations of snow. In this case, the collector may be placed on a platform that is no higher than the highest anticipated snowpack. To prevent obstructions to wind flow, the collector base should not be enclosed.

TABLE 4, PAGE 1. SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Collector Height Standard (211)	Collector on Platform (209)	Wet Bucket Orientation (215)	Ground Slope > 15° (122)
Black Belt Substn.	011000	Y	N	E	N
Denali NP	020390	Y	N	S	N
Oliver Knoll	030360	Y	N	W	N
Grand Canyon NP	030370	Y	N	W	N
Organ Pipe Cactus NM	030620	Y	N	W	N
Tanbark Flats	054200	Y	N	W	Y
Hopland	054540	Y	N	W	N
Sequoia NP-Giant For	057550	Y	N	W	Y
Montague	057680	Y	N	W	N
Chuchupate RS	058501	Y	^	W	N
Davis	058840	Y	N	W	N
Yosemite NP	058850	Y	N	W	N
Mesa Verde NP	061530	Y	N	W	N
Craters of the Moon	130343	Y	Y	W	N
Smiths Ferry	131500	N	Y	W	Y
Perryville Battle.	180360	N	Y	N	Y
Wye	211320	Y	N	W	N
Douglas Lake	230920	N	Y	W	N
Raco	230980	N	Y	W	N
Kellogg Bio. Stn.	232660	N	Y	W	N
Wellston	235340	Y	N	W	N
Newton	251960	Y	N	W	N
Custer Battle. NM	270060	Y	N	W	N
Glacier NP Fire WS	270570	Y	N	W	N
Havre Exp. Stn.	270740	Y	N	W	N
Clancy	270760	Y	Y	W	N
Give Out Morgan	271340	Y	N	W	N
Red Rock Canyon	290080	Y	N	N	N
Saval Ranch	290140	Y	N	W	N
Smith Valley	290360	Y	N	S	N
Lehman Caves NM	290560	Y	N	W	N
Gila Cliff Dwellings	320180	Y	Y	W	N
Bandelier NM	320720	Y	N	W	N
Mayhill	320840	Y	N	W	N
Cuba	320980	Y	N	W	N

(continued)

TABLE 4, PAGE 1 (cont). SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Collector Height Standard (211)	Collector on Platform (209)	Wet Bucket Orientation (215)	Ground Slope > 15° (122)
Capulin Mountain NM	321280	Y	N	W	N
Piedmont Res. Stn.	343460	Y	N	W	N
Clinton Crops RS	343560	Y	N	W	N
Jordan Creek	343600	N	N	W	N
Finley Farms	344160	Y	N	W	N
Salt Plains NWR	370060	Y	N	W	N
Great Plains Ap.	371740	Y	N	W	N
Goodwell Res. Stn.	372920	Y	N	W	N
Muleshoe NWR	450250	Y	N	W	N
Big Bend NP - K-Bar	450425	Y	N	W	N
Sonora	451650	Y	N	W	N
Guadalupe Mtns NP	452215	Y	N	W	N
Throckmorton	455180	Y	N	W	N
LBJ Natl. Grasslands	455640	Y	N	W	N
Bryce Canyon NP	460110	N	N	W	Y
Logan	460120	Y	N	W	N
Murphy Ridge	460820	Y	Y	W	N
Olympic NP Hoh RS	491410	Y	N	NW	N
Cascades NP Marble.	491940	Y	N	W	N
LaGrande	492180	Y	N	N	Y
Palouse Cons. Farm	492420	Y	N	W	Y
Yellowstone NP TF	520860	Y	N	W	N

TABLE 4, PAGE 2. SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Collector Base Open (214)	Collector-Gauge Separation (m) (236)	Collector-Gauge Heights OK (237)
Black Belt Substn.	011000	Y	2	Y
Denali NP	020390	Y	2	Y
Oliver Knoll	030360	Y	5	Y
Grand Canyon NP	030370	Y	2	Y
Organ Pipe Cactus NM	030620	Y	5	Y
Tanbark Flats	054200	Y	9	Y
Hopland	054540	Y	7	Y
Sequoia NP-Giant For	057550	^	5	Y
Montague	057680	Y	6	Y
Chuchupate RS	058501	Y	9	Y
Davis	058840	Y	5	Y
Yosemite NP	058850	Y	4	Y
Mesa Verde NP	061530	Y	4	Y
Craters of the Moon	130343	Y	5	N
Smiths Ferry	131500	Y	5	Y
Perryville Battle.	180360	Y	4	Y
Wye	211320	Y	5	Y
Douglas Lake	230920	Y	6	Y
Raco	230980	Y	6	Y
Kellogg Bio. Stn.	232660	Y	5	Y
Wellston	235340	Y	5	Y
Newton	251960	Y	5	Y
Custer Battle. NM	270060	Y	7	Y
Glacier NP Fire WS	270570	Y	5	Y
Havre Exp. Stn.	270740	Y	6	Y
Clancy	270760	Y	5	Y
Give Out Morgan	271340	Y	7	Y
Red Rock Canyon	290080	Y	3	Y
Saval Ranch	290140	Y	5	Y
Smith Valley	290360	Y	3	Y
Lehman Caves NM	290560	Y	9	Y
Gila Cliff Dwellings	320180	Y	3	N
Bandelier NM	320720	Y	6	Y
Mayhill	320840	Y	5	Y
Cuba	320980	Y	3	Y

(continued)

TABLE 4, PAGE 2 (cont). SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Collector Base Open (214)	Collector-Gauge Separation (m) (236)	Collector-Gauge Heights OK (237)
Capulin Mountain NM	321280	Y	6	N
Piedmont Res. Stn.	343460	Y	5	Y
Clinton Crops RS	343560	Y	7	Y
Jordan Creek	343600	Y	4	Y
Finley Farms	344160	Y	4	Y
Salt Plains NWR	370060	Y	5	Y
Great Plains Ap.	371740	Y	6	Y
Goodwell Res. Stn.	372920	Y	6	N
Muleshoe NWR	450250	Y	7	Y
Big Bend NP - K-Bar	450425	Y	5	Y
Sonora	451650	Y	8	Y
Guadalupe Mtns NP	452215	Y	5	Y
Throckmorton	455180	Y	6	Y
LBJ Natl. Grasslands	455640	Y	5	Y
Bryce Canyon NP	460110	Y	5	Y
Logan	460120	Y	6	Y
Murphy Ridge	460820	Y	9	Y
Olympic NP Hoh RS	491410	Y	5	Y
Cascades NP Marble.	491940	Y	4	N
LaGrande	492180	Y	4	Y
Palouse Cons. Farm	492420	Y	5	Y
Yellowstone NP TF	520860	Y	3	Y

^ = not checked.

TABLE 4, PAGE 3. SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Vegetation > 2 ft High (123)	45 degree Rule Violation (128)	Storage or Lots < 100 m (129)
Black Belt Substation	011000	N	N	N
Denali	020390	Y	N	N
Oliver Knoll	030360	N	N	N
Grand Canyon	030370	Y	N	N
Organ Pipe Cactus	030620	N	N	N
Tanbark Flats	054200	N	N	N
Hopland	054540	Y	N	N
Sequoia NP-Giant For	057550	Y	Y	N
Montague	057680	Y	N	N
Chuchupate	058501	N	N	N
Davis	058840	N	N	N
Yosemite NP	058850	N	N	N
Mesa Verde NP	061530	Y	N	N
Craters of the Moon	130343	N	N	N
Smiths Ferry	131500	N	N	N
Perryville Battle.	180360	N	N	N
Wye	211320	N	N	N
Douglas Lake	230920	N	N	N
Raco	230980	N	N	N
Kellogg Bio. Stn.	232660	Y	N	N
Wellston	235340	N	N	N
Newton	251960	Y	N	N
Custer Battle. NM	270060	N	N	N
Glacier NP Fire WS	270570	Y	Y	N
Havre Exp. Stn.	270740	N	N	N
Clancy	270760	N	N	N
Give Out Morgan	271340	N	N	N
Red Rock Canyon	290080	Y	N	N
Saval Ranch	290140	N	N	N
Smith Valley	290360	N	N	N
Lehman Caves NM	290560	Y	N	N
Gila Cliff Dwellings	320180	N	N	N
Bandelier NM	320720	Y	N	N
Mayhill	320840	Y	N	N
Cuba	320980	N	N	N

(continued)

TABLE 4, PAGE 3 (cont). SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Vegetation > 2 ft High (123)	45 degree Rule Violation (128)	Storage or Lots < 100 m (129)
Capulin Mountain NM	321280	N	N	Y
Piedmont Res. Stn.	343460	N	N	Y
Clinton Crops RS	343560	N	N	N
Jordan Creek	343600	Y	N	N
Finley Farm	344160	N	N	Y
Salt Plains NWR	370060	N	N	N
Great Plains Ap.	371740	Y	Y	Y
Goodwell Res. Stn.	372920	N	N	N
Muleshoe NWR	450250	N	N	Y
Big Bend NP - K-Bar	450425	N	N	N
Sonora	451650	N	N	N
Guadalupe Mtns NP	452215	N	N	N
Throckmorton	455180	N	N	N
LBJ Natl. Grasslands	455640	N	N	N
Bryce Canyon NP	460110	Y	N	N
Logan	460120	N	N	N
Murphy Ridge	460820	N	N	N
Olympic NP Hoh RS	491410	N	Y	Y
Cascades NP Marble.	491940	N	N	N
LaGrande	492180	N	Y	N
Palouse Cons. Farm	492420	N	N	N
Yellowstone NP TF	520860	N	N	N

TABLE 4, PAGE 4. SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Animals < 30 m (126)	Feedlots < 500 m (131)	Transit Sources < 100 m (130)
Black Belt Substation	011000	Y	N	N
Denali	020390	N	N	N
Oliver Knoll	030360	N	N	N
Grand Canyon	030370	N	N	N
Organ Pipe Cactus	030620	N	N	N
Tanbark Flats	054200	N	N	N
Hopland	054540	Y	N	N
Sequoia NP-Giant For	057550	N	N	N
Montague	057680	Y	Y	N
Chuchupate	058501	N	N	N
Davis	058840	N	N	N
Yosemite NP	058850	N	N	N
Mesa Verde NP	061530	N	N	N
Craters of the Moon	130343	N	N	N
Smiths Ferry	131500	Y	N	N
Perryville Battle.	180360	Y	N	N
Wye	211320	N	N	N
Douglas Lake	230920	N	N	N
Raco	230980	N	N	N
Kellogg Bio. Stn.	232660	N	N	N
Wellston	235340	N	N	N
Newton	251960	Y	N	N
Custer Battle. NM	270060	N	N	N
Glacier NP Fire WS	270570	N	N	N
Havre Exp. Stn.	270740	N	N	N
Clancy	270760	N	N	N
Give Out Morgan	271340	Y	N	N
Red Rock Canyon	290080	N	N	N
Saval Ranch	290140	Y	N	N
Smith Valley	290360	N	N	N
Lehman Caves NM	290560	N	N	N
Gila Cliff Dwellings	320180	Y	N	N
Bandelier NM	320720	N	N	N
Mayhill	320840	N	N	N
Cuba	320980	Y	N	N

(continued)

TABLE 4, PAGE 4 (cont). SITING CRITERIA SURVEY RESULTS

Site Name (101)	ID	Animals < 30 m (126)	Feedlots < 500 m (131)	Transit Sources < 100 m (130)
Capulin Mountain NM	321280	N	N	N
Piedmont Res. Stn.	343460	N	Y	Y
Clinton Crops RS	343560	N	N	N
Jordan Creek	343600	N	N	N
Finley Farm	344160	N	N	Y
Salt Plains NWR	370060	N	N	N
Great Plains Ap.	371740	Y	N	N
Goodwell Res. Stn.	372920	N	N	N
Muleshoe NWR	450250	N	N	N
Big Bend NP - K-Bar	450425	N	N	N
Sonora	451650	N	N	N
Guadalupe Mtns NP	452215	N	N	N
Throckmorton	455180	Y	N	N
LBJ Natl. Grasslands	455640	N	N	N
Bryce Canyon NP	460110	N	N	N
Logan	460120	Y	Y	N
Murphy Ridge	460820	N	N	N
Olympic NP Hoh RS	491410	N	N	N
Cascades NP Marble.	491940	N	N	N
LaGrande	492180	N	N	N
Palouse Cons. Farm	492420	N	N	N
Yellowstone NP TF	520860	N	N	N

Seven of 57 collectors checked (12%) were not at the standard 1-m height above ground. Of these seven, five were on platforms. The five on platforms were in areas where snowpack accumulates and warranted being on platforms. The Jordan Creek and Bryce Canyon collectors were only slightly higher than the standard 1m.

Ten of 56 collectors checked (18%) were mounted on platforms. In most cases, platforms were short, not more than 2 ft in height. The higher platforms (Smiths Ferry, ID, and Murphy Ridge, UT) were necessary to raise the collector above snowpacks. The effect of shorter platforms on the sample is believed to be minimal.

Wet Bucket Orientation--

The collector should be mounted with the wet-side bucket to the West and the sensor facing North. In this way, the wet-side bucket is generally upwind of the dry-side bucket (winds generally being from the South to Southwest in the eastern United States), and the sensor is downwind of the wet-side bucket. This placement is designed to lessen the chance of contamination and to minimize the obstruction of the collector itself to sample entry.

Of 57 site collectors examined in 1988, 50 (88%) were correctly installed with the wet bucket facing to the West. Four were installed with the wet bucket facing North or Northwest, one faced East, and two faced South. The southerly installations probably have no effect on the data. Those collectors installed with the collection bucket facing North or East may cause an aberration in the collection efficiency or sample chemistry. A statistical study of the long-term data base would be required to discern this and may be complicated by other factors. It is recommended that all collectors be oriented with the wet bucket facing West and the sensor facing North. The date this change occurs must be documented and accompany the data base.

Ground Slope--

The collector should not be located on ground with a slope greater than 15° from the horizontal. The slope at six of 57 sites (11% of the total) did not meet this criterion. However, all six sites are located in hilly or mountainous regions, and thus their ground slopes are representative of the region.

It is difficult to say what the effect of the steeper slopes is on collection efficiencies. However, to adhere too rigidly to the criterion would effectively rule out sites in many regions, especially those at higher elevations.

Collector Base Open--

The base of the Aerochem Metrics collector should be open. Enclosing the base may cause turbulence in the vicinity of the collector and affect catch efficiency or cause sample contamination. None of the 57 collectors examined in 1988 had the base enclosed.

Collector-Gauge Separation--

The collector should be located within a distance of 30 m of the rain gauge but no closer than 5 m. This guideline is set so that the collector and gauge "see" the same precipitation event and so that neither piece of equipment is an aerodynamic interference to the other's collection ability.

Fifteen of 57 sites (26%) had rain gauges less than 5 m from the collector. Of these, seven were separated by 4 m, five by 3 m, and three by 2 m. Six sites not meeting the distance requirement were enclosed by fences for security. For these cases, meeting the separation distance requirement would involve enlarging the enclosure or building a separate one. The nine sites that were not enclosed by a fence should have their gauges removed to the proper distance, and the move should be documented. None of the sites exceeded the recommended separation distance of 30 m.

Collector and Rain Gauge at Same Height--

The heights above ground of the collection bucket rim and the rain gauge orifice should be within 1 ft of each other. Five of 57 sites (9%) did not meet this criterion. However, in all cases, the criterion was exceeded by small amounts (3 to 4 in.); the effect on the data base is probably negligible.

Immediate Site Surroundings--

Pages 3 and 4 of Table 4 give results related to the siting criteria for the area within a 500-m radius of the precipitation collector. The purpose of

these criteria is to minimize the presence of sources and obstructions that may cause sample contamination or affect collection efficiency. The presence of urban areas or industry at distances of 10 km or greater from the site is not considered in this report, because this information has already been given in the report of the first round of site visits made in 1985-1986, and the site site locations have not changed substantially since that time.

Vegetation within 30 m and the 45° rule -- Vegetation within 30 m of the collector should not be more than 2 ft tall, and no object should project on the collector from an angle greater than 45°. These criteria are intended to keep windblown contaminants such as seeds or splashing water out of the collection bucket and to prevent shadowing of the rain by tall objects.

Fifteen of 57 sites (26%) had vegetation of height greater than 2 ft within 30 m of the collector. Five sites (9%) had trees or towers too near the collectors, thus violating the 45° siting criterion. Under certain wind conditions, it is possible that rain splashing from these objects into the collection bucket could significantly alter the sample chemistry or that the intensity of the rainfall could be affected.

Parking lots, chemical storage -- The site should not be within 100 m of parking lots or chemical storage. Three of 57 sites (5%) did not satisfy this criterion.

Grazing animals or feedlots -- The site should be more than 30 m from grazing animals and more than 500 m from large concentrations of animals such as feedlots, dairy farms, or poultry farms. These criteria are intended to ensure sources of dust and ammonia compounds (which could neutralize acidic solutions) are well away from the collector. Thirteen of the 57 (23%) sites examined in 1988 were near grazing animals. The effect is probably negligible because the animals in these situations tend to roam over large areas and are not concentrated near the site. Three sites (5%) were within 500 m of feedlots or other large concentrations of animals which may affect a sample's chemistry.

Transit sources closer than 100 m -- Transit sources such as well-traveled roads, railroads, and shipping channels should be no closer than 100 m to the sample collector. Two of 57 sites (4%) were judged to be too near paved roads.

EQUIPMENT AND SAMPLE COLLECTION SURVEY

System and performance checks were made at each site to assess the operational fitness of the Aerochem Metrics precipitation collector and the Belfort rain gauge. The process of sample retrieval and care was also examined. These are discussed below.

Precipitation Collector System Checks

A discussion of the results of precipitation collector systems checks is presented in Table 5.

Power Type--

Thirty-one (54%) of the 57 collectors examined in 1988 were powered by alternating current (AC) source only. Nine (16%) have AC power along with a trickle-charged battery back-up. Fifteen sites (25%) were powered by solar panels or battery. Two were powered by battery only. The most desirable arrangement is AC power combined with a trickle-charged battery.

Collector Level--

The precipitation collector should be level so that the collection efficiency is not biased by wind direction or variations in effective bucket-opening areas. All 57 collectors examined were level.

Collector Stable--

The precipitation collector should be mounted firmly so that it will not move in strong winds. Each of the 57 collectors examined was judged to be stably mounted (i.e., it could not be rocked easily by hand).

Sensor Clean--

The collector's sensor should be clean. All but one of the 57 collector sensors examined were clean. The usual effect of a dirty sensor is to prolong the length of time the wet bucket stays uncovered after an event, increasing the likelihood of sample contamination and evaporation.

TABLE 5, PAGE 1. AEROCHEM METRICS COLLECTOR SYSTEM CHECKS

Site Name (101)	ID	Power Type * (202)	Collector Level (212)	Collector Stable (213)
Black Belt Substn.	011000	E	Y	Y
Denali NP	020390	A	Y	Y
Oliver Knoll	030360	E	Y	Y
Grand Canyon NP	030370	A	Y	Y
Organ Pipe Cactus NM	030620	B	Y	Y
Tanbark Flats	054200	B	Y	Y
Hopland	054540	A	Y	Y
Sequoia NP-Giant For	057550	A	Y	Y
Montague	057680	B	Y	Y
Chuchupate RS	058501	B	Y	Y
Davis	058840	A	Y	Y
Yosemite NP	058850	A	Y	Y
Mesa Verde NP	061530	A	Y	Y
Craters of the Moon	130343	A	Y	Y
Smiths Ferry	131500	E	Y	Y
Perryville Battle.	180360	C	Y	Y
Wye	211320	A	Y	Y
Douglas Lake	230920	A	Y	Y
Raco	230980	B	Y	Y
Kellogg Bio. Stn.	232660	A	Y	Y
Wellston	235340	A	Y	Y
Newton	251960	A	Y	Y
Custer Battle. NM	270060	E	Y	Y
Glacier NP Fire WS	270570	A	Y	Y
Havre Exp. Stn.	270740	B	Y	Y
Clancy	270760	B	Y	Y
Give Out Morgan	271340	A	Y	Y
Red Rock Canyon	290080	C	Y	Y
Saval Ranch	290140	A	Y	Y
Smith Valley	290360	E	Y	Y
Lehman Caves NM	290560	E	Y	Y
Gila Cliff Dwellings	320180	B	Y	Y
Bandelier NM	320720	A	Y	Y
Mayhill	320840	A	Y	Y
Cuba	320980	E	Y	Y

(continued)

TABLE 5, PAGE 1 (cont). AEROCHEM METRICS COLLECTOR SYSTEM CHECKS

Site Name (101)	ID	Power Type * (202)	Collector Level (212)	Collector Stable (213)
Capulin Mountain NM	321280	A	Y	Y
Piedmont Res. Stn.	343460	A	Y	Y
Clinton Crops RS	343560	A	Y	Y
Jordan Creek	343600	E	Y	Y
Finley Farms	344160	A	Y	Y
Salt Plains NWR	370060	E	Y	Y
Great Plains Ap.	371740	A	Y	Y
Goodwell Res. Stn.	372920	E	Y	Y
Muleshoe NWR	450250	B	Y	Y
Big Bend NP - K-Bar	450425	A	Y	Y
Sonora	451650	E	Y	Y
Guadalupe Mtns NP	452215	E	Y	Y
Throckmorton	455180	E	Y	Y
LBJ Natl. Grasslands	455640	A	Y	Y
Bryce Canyon NP	460110	A	Y	Y
Logan	460120	A	Y	Y
Murphy Ridge	460820	E	Y	Y
Olympic NP Hoh RS	491410	A	Y	Y
Cascades NP Marble.	491940	A	Y	Y
LaGrande	492180	E	Y	Y
Palouse Cons. Farm	492420	A	Y	Y
Yellowstone NP TF	520860	A	Y	Y

* (A) AC only; (B) AC w/ Aerochem trickle charger/battery; (C) Battery only; (D) Battery w/ external AC powered charger; (E) Solar; (F) Other.

TABLE 5, PAGE 2. AEROCHEM METRICS COLLECTOR SYSTEM CHECKS

Site Name (101)	ID	Sensor Clean (218)	Bucket Tie-down Used (222)	Correct Counter-Weight (232)	Clutch Worn (234)
Black Belt Substn.	011000	Y	N	Y	N
Denali NP	020390	Y	Y	^	^
Oliver Knoll	030360	Y	Y	Y	Y
Grand Canyon NP	030370	Y	Y	Y	Y
Organ Pipe Cactus NM	030620	Y	Y	Y	N
Tanbark Flats	054200	Y	Y	Y	N
Hopland	054540	Y	Y	Y	N
Sequoia NP-Giant For	057550	Y	Y	Y	Y
Montague	057680	Y	Y	Y	N
Chuchupate RS	058501	Y	Y	Y	N
Davis	058840	Y	Y	Y	N
Yosemite NP	058850	Y	Y	Y	N
Mesa Verde NP	061530	Y	Y	Y	N
Craters of the Moon	130343	Y	Y	Y	N
Smiths Ferry	131500	Y	Y	Y	N
Perryville Battle.	180360	Y	Y	Y	N
Wye	211320	Y	Y	Y	N
Douglas Lake	230920	Y	Y	Y	Y
Raco	230980	Y	Y	Y	N
Kellogg Bio. Stn.	232660	Y	Y	^	N
Wellston	235340	Y	N	Y	N
Newton	251960	Y	Y	Y	N
Custer Battle. NM	270060	Y	Y	Y	N
Glacier NP Fire WS	270570	Y	Y	N	Y
Havre Exp. Stn.	270740	Y	Y	Y	N
Clancy	270760	Y	Y	Y	Y
Give Out Morgan	271340	Y	Y	Y	N
Red Rock Canyon	290080	Y	Y	Y	N
Saval Ranch	290140	Y	Y	Y	Y
Smith Valley	290360	Y	Y	Y	N
Lehman Caves NM	290560	Y	N	Y	N
Gila Cliff Dwellings	320180	Y	Y	Y	N
Bandelier NM	320720	Y	N	Y	N
Mayhill	320840	Y	Y	Y	Y
Cuba	320980	Y	Y	Y	N

(continued)

TABLE 5, PAGE 2 (cont). AEROCHEM METRICS COLLECTOR SYSTEM CHECKS

Site Name (101)	ID	Sensor Clean (218)	Bucket Tie-down Used (222)	Correct Counter-Weight (232)	Clutch Worn (234)
Capulin Mountain NM	321280	N	Y	Y	N
Piedmont Res. Stn.	343460	Y	Y	Y	N
Clinton Crops RS	343560	Y	Y	Y	N
Jordan Creek	343600	Y	N	Y	N
Finley Farms	344160	Y	Y	Y	N
Salt Plains NWR	370060	Y	Y	Y	N
Great Plains Ap.	371740	Y	Y	Y	N
Goodwell Res. Stn.	372920	Y	Y	Y	Y
Muleshoe NWR	450250	Y	Y	Y	Y
Big Bend NP - K-Bar	450425	Y	Y	Y	N
Sonora	451650	Y	Y	Y	N
Guadalupe Mtns NP	452215	Y	Y	Y	N
Throckmorton	455180	Y	Y	Y	N
LBJ Natl. Grasslands	455640	Y	Y	Y	Y
Bryce Canyon NP	460110	Y	N	Y	N
Logan	460120	Y	N	Y	Y
Murphy Ridge	460820	Y	Y	Y	N
Olympic NP Hoh RS	491410	Y	Y	Y	Y
Cascades NP Marble.	491940	Y	Y	Y	N
LaGrande	492180	Y	Y	Y	N
Palouse Cons. Farm	492420	Y	Y	Y	N
Yellowstone NP TF	520860	Y	Y	Y	N

^ = not checked.

Bucket Tie Down--

Both the wet and dry collection buckets should be secured to the collector with tie-down straps to prevent their being blown out during strong winds. Seven of the 57 sites (12%) did not secure the buckets. However, the actual incidence of sample loss due to this variance probably is very low.

Counterweight--

The moving bucket lid should be properly counterweighted so the lid can be moved without excessive motor strain or clutch slippage. Sites which have added snow roofs also need to add a counterweight. Only one of 55 site collectors examined had a missing counterweight. Excessive clutch wear was noted for it.

Clutch Wear--

The motor box clutch assembly should not show signs of excessive slippage or wear as evidenced by a shiny clutch surface or rounded-off indent. Thirteen of 56 sites examined (23%) had evidence of clutch wear or slippage. However, a test of the assembly's ability to lift two or more Belfort gauge weights without the clutch slipping showed that 11 of the 13 were operating properly. The Logan, UT, and Olympic National Park, WA, collector clutches were weak. The usual result of serious clutch slippage is that a sample is not collected because the bucket lid fails to move off the wet bucket at the start of a pre cipitation event.

Precipitation Collector Performance Checks

Table 6 lists the results of performance checks conducted on the Aerochem Metrics precipitation collectors.

Cover Seats Properly on Wet Bucket--

The collector's bucket cover should fit tightly and evenly on the rim of the wet (and dry) bucket so that dust cannot enter during dry periods (and so that the lid liner is protected during wet periods). None of 56 collectors that could be examined in 1988 had bucket-lid seal problems.

TABLE 6, PAGE 1. AEROCHEM METRICS COLLECTOR PERFORMANCE CHECKS

Site Name (101)	ID	No Gaps; Bucket-lid Seal (243)	Lid Tension (g) (241)	Lid Drop (mm) (254)	Voltage to Event Marker (250)
Black Belt Substn.	011000	Y	1900	14	12.19
Denali NP	020390	^	^	^	^
Oliver Knoll	030360	Y	2500	12	14.39
Grand Canyon NP	030370	Y	2300	11	12.93
Organ Pipe Cactus NM	030620	Y	2300	15	12.56
Tanbark Flats	054200	Y	3200	16	13.14
Hopland	054540	Y	2700	24	13.01
Sequoia NP-Giant For	057550	Y	3000	13	12.74
Montague	057680	Y	2500	12	12.60
Chuchupate RS	058501	Y	2700	14	12.09
Davis	058840	Y	2000	16	16.00
Yosemite NP	058850	Y	2000	5	10.41
Mesa Verde NP	061530	Y	2500	12	12.07
Craters of the Moon	130343	Y	2000	21	12.55
Smiths Ferry	131500	Y	2000	12	13.30
Perryville Battle.	180360	Y	2700	8	11.41
Wye	211320	Y	2000	18	11.04
Douglas Lake	230920	Y	3000	12	12.00
Raco	230980	Y	1900	14	13.15
Kellogg Bio. Stn.	232660	Y	^	^	^
Wellston	235340	Y	2700	16	12.87
Newton	251960	Y	2800	21	11.40
Custer Battle. NM	270060	Y	2500	17	12.58
Glacier NP Fire WS	270570	Y	1500	20	11.90
Havre Exp. Stn.	270740	Y	3000	15	12.92
Clancy	270760	Y	2000	15	13.02
Give Out Morgan	271340	Y	3000	16	13.40
Red Rock Canyon	290080	Y	2500	15	12.15
Saval Ranch	290140	Y	2000	15	13.10
Smith Valley	290360	Y	2500	14	14.41
Lehman Caves NM	290560	Y	2000	14	12.36
Gila Cliff Dwellings	320180	Y	2000	11	13.27
Bandelier NM	320720	Y	2500	19	11.70
Mayhill	320840	Y	2500	18	13.30
Cuba	320980	Y	2200	13	11.82

(continued)

TABLE 6, PAGE 1 (cont). AEROCHEM METRICS COLLECTOR PERFORMANCE CHECKS

Site Name (101)	ID	No Gaps; Bucket-lid Seal (243)	Lid Tension (g) (241)	Lid Drop (mm) (254)	Voltage to Event Marker (250)
Capulin Mountain NM	321280	Y	2000	8	12.87
Piedmont Res. Stn.	343460	Y	3000	15	13.04
Clinton Crops RS	343560	Y	3200	16	13.27
Jordan Creek	343600	Y	3000	14	12.75
Finley Farms	344160	Y	3500	22	12.13
Salt Plains NWR	370060	Y	2500	15	11.76
Great Plains Ap.	371740	Y	2500	18	12.98
Goodwell Res. Stn.	372920	Y	2500	15	12.70
Muleshoe NWR	450250	Y	2500	22	12.70
Big Bend NP - K-Bar	450425	Y	2500	13	12.58
Sonora	451650	Y	2500	15	11.95
Guadalupe Mtns NP	452215	Y	2500	20	13.49
Throckmorton	455180	Y	2300	18	11.86
LBJ Natl. Grasslands	455640	Y	2500	20	13.04
Bryce Canyon NP	460110	Y	2300	21	12.70
Logan	460120	Y	2000	12	12.11
Murphy Ridge	460820	Y	2300	10	12.60
Olympic NP Hoh RS	491410	Y	2000	18	12.92
Cascades NP Marble.	491940	Y	2500	16	12.52
LaGrande	492180	Y	2300	13	13.40
Palouse Cons. Farm	492420	Y	2600	8	12.80
Yellowstone NP TF	520860	Y	1500	8	^

^ = not checked.

TABLE 6, PAGE 2. AEROCHEM METRICS COLLECTOR PERFORMANCE CHECKS

Site Name (101)	ID	Sensor Temp, Ambient, °C (239)	Sensor Temp, Activated, °C (251)	Resistance to Trigger Sensor, K ohm (257)
Black Belt Substn.	011000	30	47	87
Denali NP	020390	^	^	^
Oliver Knoll	030360	8	47	89
Grand Canyon NP	030370	29	53	76
Organ Pipe Cactus NM	030620	16	30	82
Tanbark Flats	054200	15	50	76
Hopland	054540	22	56	82
Sequoia NP-Giant For	057550	19	50	73
Montague	057680	15	60	84
Chuchupate RS	058501	15	48	89
Davis	058840	16	55	71
Yosemite NP	058850	23	61	80
Mesa Verde NP	061530	21	43	82
Craters of the Moon	130343	25	71	87
Smiths Ferry	131500	16	55	74
Perryville Battle.	180360	44	70	73
Wye	211320	28	59	83
Douglas Lake	230920	16	46	^
Raco	230980	16	53	83
Kellogg Bio. Stn.	232660	^	^	^
Wellston	235340	17	52	93
Newton	251960	33	54	88
Custer Battle. NM	270060	40	76	83
Glacier NP Fire WS	270570	30	73	83
Havre Exp. Stn.	270740	25	58	78
Clancy	270760	14	72	82
Give Out Morgan	271340	34	50	88
Red Rock Canyon	290080	18	18	83
Saval Ranch	290140	29	57	79
Smith Valley	290360	29	61	104
Lehman Caves NM	290560	30	56	90
Gila Cliff Dwellings	320180	26	51	82
Bandelier NM	320720	32	46	82
Mayhill	320840	19	67	90
Cuba	320980	35	35	83

(continued)

TABLE 6, PAGE 2 (cont). AEROCHEM METRICS COLLECTOR PERFORMANCE CHECKS

Site Name (101)	ID	Sensor Temp, Ambient, °C (239)	Sensor Temp, Activated, °C (251)	Resistance to Trigger Sensor, K ohm (257)
Capulin Mountain NM	321280	14	39	92
Piedmont Res. Stn.	343460	21	54	90
Clinton Crops RS	343560	17	50	78
Jordan Creek	343600	37	46	89
Finley Farms	344160	8	44	87
Salt Plains NWR	370060	18	30	74
Great Plains Ap.	371740	14	35	94
Goodwell Res. Stn.	372920	12	29	77
Muleshoe NWR	450250	9	30	64
Big Bend NP - K-Bar	450425	11	34	91
Sonora	451650	19	46	79
Guadalupe Mtns NP	452215	16	42	81
Throckmorton	455180	17	41	78
LBJ Natl. Grasslands	455640	30	58	85
Bryce Canyon NP	460110	15	39	82
Logan	460120	22	53	64
Murphy Ridge	460820	19	60	73
Olympic NP Hoh RS	491410	16	54	73
Cascades NP Marble.	491940	29	62	68
LaGrande	492180	30	54	83
Palouse Cons. Farm	492420	23	54	80
Yellowstone NP TF	520860	37	70	89

^ = not checked.

Lid Tension--

The force that the bucket cover exerts against the rim of the collection bucket may be assessed by lifting the lid slightly above the bucket rim and reading the force (in grams) required to do so. A spring scale is used. Generally, tensions of 1500 g or greater are found. Collectors at two sites (Glacier NP and Yellowstone NP) had lid tensions of only 1500 g. All the rest had tensions ranging from 1900 to 3500 g. The average lid tension was 2425 $\pm$ 419 g.

Lid Drop Distance--

Another measure of adequate lid/bucket seal tension is the lid drop distance--the distance the lid drops when the wet bucket is removed. The Central Analytical Laboratory of the NADP/NTN network has found that a lid drop distance of at least 3 mm is associated with good, dust-free seals. Of 55 site collectors checked, none had a lid drop distance of 3 mm or less. Minimum, maximum, and mean distances were 5, 24, and 14.7 $\pm$ 7.5 mm.

Voltage to Event Marker--

In the wet-side open mode, the Aerochem Metrics unit should send a signal of 14 $\pm$ 3 V to the event marker solenoid of the Belfort rain gauge. Zero voltage or values outside the prescribed range are indications of problems with the Aerochem Metrics motor box or the battery, if one is used to power the unit. Of 54 units checked, only one (Yosemite NP) was lower than the acceptable voltage range. The mean voltage was 12.67 $\pm$ 0.86.

Unactivated Sensor Temperature--

Generally, the temperature of the precipitation collector sensor is at ambient level when there is no precipitation. If it is a sunny day, the metal surfaces may be warmer than the ambient air temperature. If the ambient temperature is below 4°C, the sensor heater should come on, at a lower power level, to be prepared to melt ice or snow that may fall. A sensor should not be heating when ambient temperatures are above 4°C unless it is raining. If it is heating prior to the rain, light rainfall striking the sensor may evaporate before the circuit can be made to open the lid. None of the 55 sensors checked showed irregular heating at ambient temperatures.

Activated Sensor Temperature--

When activated by precipitation, the Aerochem Metrics sensor causes the cover to move off the wet-side collection bucket. To speed precipitation evaporation and thus reduce the time the wet-side bucket is open after precipitation ceases, a heater circuit beneath the base plate of the sensor is energized, and the temperature of the sensor (as measured at the base plate) rises. The circuit is thermistor-limited and is factory-adjusted to reach 50-60°C (122-140°F) maximum temperature.

A total of 55 sensors were checked during the 1988 visits. Sensors at two other sites visited were not checked because heavy rains were occurring at the time of the visit. Of the 55, one (Red Rock Canyon) was not heating, one (Cuba) was heating at all times, and 53 (96%) were judged to be heating properly. Sensor temperatures were checked by using a thermocouple and digital meter. The lowest temperature of the operating sensors was 29°C (Goodwell), the highest was 76°C (Custer Battlefield), and the average temperature was 50.1 $\pm$ 14.8°C. Of those 53 judged to be heating properly, 20 (38%) heated below 50°C, 23 (43%) heated within the manufactured range of 50-60°C, and 10 (19%) heated above 60°C.

Resistance to Trigger Sensor--

The sensor of the Aerochem Metrics collector activates circuitry to open the cover when water droplets bridge the gap between the grid and the baseplate elements of the sensor assembly. According to factory specifications, this occurs when the resistance between the elements is reduced to 80KΩ. This resistance is sufficiently sensitive to cause activation by relatively pure water (i.e., water of very low conductivity, such as deionized water).

All of the 54 sensors checked caused the circuit to activate when distilled water was applied to the grid and baseplate. The low, high, and average resistances measured by bridging the grid and the baseplate through a variable resistance box were 64, 104, and 81 $\pm$ 12KΩ, respectively.

Rain Gauge System Checks

Results of five system checks of the installation and operation of the Belfort gauge are given in Table 7. Also included is a column indicating that 24 of the 56 gauges checked (43%) were calibrated during the site visit.

TABLE 7, PAGE 1. BELFORT RAIN GAUGE SYSTEM CHECKS

Site Name (101)	ID	Gauge Level (302)	Orifice Round (305)	Alter Shield (310)
Black Belt Substn.	011000	Y	Y	N
Denali NP	020390	Y	Y	N
Oliver Knoll	030360	Y	Y	Y
Grand Canyon NP	030370	Y	Y	N
Organ Pipe Cactus NM	030620	Y	Y	N
Tanbark Flats	054200	Y	Y	N
Hopland	054540	Y	Y	N
Sequoia NP-Giant For	057550	Y	Y	Y
Montague	057680	Y	Y	Y
Chuchupate RS	058501	Y	Y	N
Davis	058840	Y	Y	N
Yosemite NP	058850	Y	Y	N
Mesa Verde NP	061530	Y	Y	N
Craters of the Moon	130343	Y	Y	N
Smiths Ferry	131500	Y	Y	Y
Perryville Battle.	180360	Y	Y	N
Wye	211320	Y	Y	N
Douglas Lake	230920	Y	Y	N
Raco	230980	Y	Y	N
Kellogg Bio. Stn.	232660	Y	Y	N
Wellston	235340	Y	Y	Y
Newton	251960	Y	Y	N
Custer Battle. NM	270060	Y	Y	N
Glacier NP Fire WS	270570	Y	Y	N
Havre Exp. Stn.	270740	Y	Y	Y
Clancy	270760	Y	Y	Y
Give Out Morgan	271340	Y	Y	N
Red Rock Canyon	290080	Y	Y	N
Saval Ranch	290140	Y	Y	Y
Smith Valley	290360	Y	Y	Y
Lehman Caves NM	290560	Y	Y	N
Gila Cliff Dwellings	320180	Y	Y	N
Bandelier NM	320720	Y	Y	N
Mayhill	320840	Y	Y	N
Cuba	320980	Y	Y	N

(continued)

TABLE 7, PAGE 1 (cont). BELFORT RAIN GAUGE SYSTEM CHECKS

Site Name (101)	ID	Gauge Level (302)	Orifice Round (305)	Alter Shield (310)
Capulin Mountain NM	321280	Y	Y	N
Piedmont Res. Stn.	343460	Y	Y	N
Clinton Crops RS	343560	N	Y	N
Jordan Creek	343600	Y	Y	N
Finley Farms	344160	Y	Y	N
Salt Plains NWR	370060	Y	Y	N
Great Plains Ap.	371740	Y	Y	N
Goodwell Res. Stn.	372920	Y	Y	N
Muleshoe NWR	450250	Y	Y	Y
Big Bend NP - K-Bar	450425	Y	Y	N
Sonora	451650	Y	Y	N
Guadalupe Mtns NP	452215	Y	Y	N
Throckmorton	455180	Y	Y	N
LBJ Natl. Grasslands	455640	Y	Y	N
Bryce Canyon NP	460110	Y	Y	N
Logan	460120	Y	Y	N
Murphy Ridge	460820	Y	Y	Y
Olympic NP Hoh RS	491410	Y	Y	N
Cascades NP Marble.	491940	Y	Y	N
LaGrande	492180	Y	Y	N
Palouse Cons. Farm	492420	Y	Y	Y
Yellowstone NP TF	520860	Y	Y	N

TABLE 7, PAGE 2. BELFORT RAIN GAUGE SYSTEM CHECKS

Site Name (101)	ID	Time Correct +/- 1 h (322)	Dampening Fluid OK (327)	Gauge Calibrated by RTI (332)
Black Belt Substn.	011000	Y	Y	Y
Denali NP	020390	N	^	^
Oliver Knoll	030360	Y	Y	Y
Grand Canyon NP	030370	Y	Y	N
Organ Pipe Cactus NM	030620	Y	Y	Y
Tanbark Flats	054200	Y	Y	N
Hopland	054540	Y	Y	N
Sequoia NP-Giant For	057550	Y	Y	Y
Montague	057680	Y	Y	Y
Chuchupate RS	058501	N	Y	N
Davis	058840	Y	N	N
Yosemite NP	058850	Y	Y	N
Mesa Verde NP	061530	Y	N	Y
Craters of the Moon	130343	Y	Y	Y
Smiths Ferry	131500	Y	Y	N
Perryville Battle.	180360	Y	Y	Y
Wye	211320	^	Y	N
Douglas Lake	230920	Y	Y	N
Raco	230980	Y	Y	Y
Kellogg Bio. Stn.	232660	Y	Y	Y
Wellston	235340	Y	Y	N
Newton	251960	Y	N	Y
Custer Battle. NM	270060	Y	Y	N
Glacier NP Fire WS	270570	Y	Y	N
Havre Exp. Stn.	270740	Y	Y	N
Clancy	270760	^	Y	N
Give Out Morgan	271340	N	Y	Y
Red Rock Canyon	290080	Y	Y	Y
Saval Ranch	290140	Y	N	N
Smith Valley	290360	Y	Y	Y
Lehman Caves NM	290560	Y	Y	N
Gila Cliff Dwellings	320180	N	N	N
Bandelier NM	320720	Y	Y	Y
Mayhill	320840	Y	Y	Y
Cuba	320980	Y	N	N

(continued)

TABLE 7, PAGE 2 (cont). BELFORT RAIN GAUGE SYSTEM CHECKS

Site Name (101)	ID	Time Correct +/- 1 h (322)	Dampening Fluid OK (327)	Gauge Calibrated by RTI (332)
Capulin Mountain NM	321280	N	N	Y
Piedmont Res. Stn.	343460	Y	Y	Y
Clinton Crops RS	343560	Y	Y	Y
Jordan Creek	343600	Y	Y	N
Finley Farms	344160	Y	Y	Y
Salt Plains NWR	370060	Y	Y	N
Great Plains Ap.	371740	Y	N	N
Goodwell Res. Stn.	372920	Y	Y	N
Muleshoe NWR	450250	Y	Y	N
Big Bend NP - K-Bar	450425	Y	Y	N
Sonora	451650	Y	Y	N
Guadalupe Mtns NP	452215	Y	Y	N
Throckmorton	455180	N	Y	N
LBJ Natl. Grasslands	455640	Y	Y	N
Bryce Canyon NP	460110	Y	N	Y
Logan	460120	Y	Y	Y
Murphy Ridge	460820	Y	Y	Y
Olympic NP Hoh RS	491410	N	Y	N
Cascades NP Marble.	491940	Y	Y	N
LaGrande	492180	N	Y	N
Palouse Cons. Farm	492420	Y	Y	N
Yellowstone NP TF	520860	Y	N	Y

^ = not checked.

Gauge Level--

The rain gauge should be level so that precipitation collection efficiency is not biased by wind direction or by variation in effective exposure area. Only one of the 57 rain gauges inspected was out of level. This was immediately corrected.

Opening Round--

The Belfort rain gauge calibration relationship requires that the collection orifice be a circular orifice, 8 in. in diameter. An out-of-round orifice may alter the cross-sectional area of the orifice and hence the gauge calibration. None of the 57 gauges examined were out-of-round by more than 1/8 in. (based on two measurements of the diameters made at right angles to each other).

Alter Shields--

Alter shields may be used with rain gauges in the NADP/NTN network to abate strong winds near the gauge and improve collection efficiency. Twelve of the 57 sites (21%) were so equipped.

Chart Recorders--

When checked at the time of the visit, the chart recorders should indicate the correct time $\pm$ 1 h. The rain gauge chart recorder was off by more than 1 h at eight of the 55 sites checked.

Dampening Fluid Levels--

The Belfort gauge dampening fluid reservoir should be filled to within 0.25 in. of the top to reduce pen "noise" created by strong winds. Charts showing excessive pen noise are difficult to read accurately. The dampening fluid level was low at 10 (18%) of the 56 sites checked.

Rain Gauge Performance Check

The rain gauge calibration was checked by using Belfort gauge calibration weights. Results of the checks for 1988 are shown in Table 8. Forty-eight of the 56 gauges (86%) were in calibration (within $\pm$ 0.1 in.) through 5-in. depth. At a depth of 6 in., only 77% were in calibration. Calibration errors

TABLE 8. BELFORT RAIN GAUGE PERFORMANCE CHECKS

Site Name	Depth at Which Check Exceeds +/- 0.1 in. Agreement											
	1	2	3	4	5	6	7	8	9	10	11	12
Black Belt Substn.	-	-	-	-	-	-	-	-	X	X	X	^
Denali NP	^	^	^	^	^	^	^	^	^	^	^	^
Oliver Knoll	-	-	-	-	-	-	-	-	-	-	-	-
Grand Canyon NP	-	-	-	-	-	-	-	-	-	-	-	-
Organ Pipe Cactus NM	-	-	-	-	X	-	-	-	X	X	X	^
Tanbark Flats	-	-	-	-	-	-	-	-	-	-	-	-
Hopland	-	-	-	-	-	-	-	-	-	-	-	-
Sequoia NP-Giant For.	-	-	-	-	-	X	X	X	X	X	X	^
Montague	-	-	-	-	-	-	-	-	-	-	-	-
Chuchupate RS	-	-	-	-	-	-	-	-	-	-	-	-
Davis	-	-	-	-	-	-	X	X	X	X	X	X
Yosemite NP	-	-	-	-	X	X	X	-	-	-	-	-
Mesa Verde NP	-	-	-	-	-	X	X	X	X	X	X	X
Craters of the Moon	-	-	-	-	-	-	-	-	-	-	-	-
Smiths Ferry	-	-	-	-	-	-	-	-	-	-	^	^
Perryville Battle.	-	-	-	-	-	-	X	X	-	X	X	X
Wye	-	-	-	-	-	-	-	-	-	-	-	-
Douglas Lake	-	-	-	-	-	-	-	-	-	-	-	-
Raco	-	-	-	-	-	X	X	X	X	X	X	X
Kellogg Bio. Stn.	-	-	-	X	X	-	-	X	X	X	X	X
Wellston	-	-	-	-	-	-	-	-	-	-	-	-
Newton	-	-	-	-	-	X	X	X	X	X	-	-
Custer Battle. NM	-	-	-	-	-	-	-	-	-	-	-	-
Glacier NP Fire WS	-	-	-	-	-	-	-	-	-	-	-	-
Havre Exp. Stn.	-	-	-	-	-	-	-	-	-	-	-	-
Clancy	-	-	-	-	-	-	-	-	-	-	-	-
Give Out Morgan	-	-	-	-	-	-	-	-	-	X	X	X
Red Rock Canyon	-	-	-	-	-	-	X	X	X	X	X	X
Saval Ranch	-	-	-	-	-	-	-	-	-	-	-	-
Smith Valley	-	-	-	-	-	-	X	X	X	X	X	X
Lehman Caves NM	-	-	-	-	-	-	-	-	-	-	-	-
Gila Cliff Dwellings	-	-	-	-	-	-	-	-	-	-	-	-
Bandelier NM	-	-	-	-	-	-	-	-	-	-	-	X
Mayhill	-	-	-	-	-	-	-	-	-	-	-	X
Cuba	-	-	-	-	-	-	-	-	-	-	-	-

(continued)

TABLE 8 (cont). BELFORT RAIN GAUGE PERFORMANCE CHECKS

Site Name	Depth at Which Check Exceeds +/- 0.1 in. Agreement											
	1	2	3	4	5	6	7	8	9	10	11	12
Capulin Mountain NM	-	-	-	-	-	x	-	x	x	x	x	-
Piedmont Res. Stn.	-	-	-	-	-	-	x	-	-	x	x	x
Clinton Crops RS	-	-	-	-	-	-	-	-	-	-	x	x
Jordan Creek	-	-	-	-	-	-	-	-	-	-	-	-
Finley Farms	-	-	-	-	-	-	-	x	x	x	x	-
Salt Plains NWR	-	-	-	x	x	x	x	x	x	-	-	-
Great Plains Ap.	-	-	-	-	-	-	-	-	-	-	-	^
Goodwell Res. Stn.	-	-	-	x	x	x	-	-	-	-	-	^
Muleshoe NWR	x	x	x	x	x	^	-	-	-	x	x	x
Big Bend NP - K-Bar	-	-	-	-	-	-	-	-	-	-	-	-
Sonora	x	x	x	x	x	x	-	-	-	-	-	-
Guadalupe Mtns. NP	-	-	-	-	-	-	-	-	-	-	-	-
Throckmorton	-	-	-	-	-	-	-	-	-	-	-	-
LBJ Natl. Grasslands	-	-	-	-	-	-	-	-	-	-	-	-
Bryce Canyon NP	-	-	-	-	-	-	-	-	-	-	-	-
Logan	-	-	-	x	x	-	x	x	x	x	x	-
Murphy Ridge	-	-	-	-	-	-	x	x	x	x	x	x
Olympic NP Hoh. RS	-	-	-	-	-	-	x	x	x	x	x	x
Cascades NP Marble.	-	-	-	-	-	-	-	-	-	-	-	-
LaGrande	-	-	-	-	-	-	-	-	-	-	-	-
Palouse Cons. Farm	-	-	-	-	-	-	x	x	x	x	x	x
Yellowstone NP TF	-	-	-	-	-	-	x	x	x	x	x	x

Key: - = OK x = outside +/- 0.1 in. ^ = not checked.

associated with the crossover point increase at the 6-in. depth point. Because most rain amounts are measured in the zero through 5-in. range (except when winterized), and because an event's depth is measured as the difference in chart reading before and after the event, errors in precipitation depth measurements due to inaccurate rain gauge calibration are minimized. Twenty-four of the 56 rain gauges checked (43%) were calibrated at the time of the site visits.

Sample Collection Procedures

Sample collection procedures were discussed with site operators to verify specified procedures were being followed. Key among these are five procedures listed below and shown with results in Table 9.

1. Is the collection bucket held only on the outside? Special care should be taken to avoid contaminating the precipitation sample.

2. Is the sample bucket changed every seven days, on Tuesday? The sample bucket should be changed every Tuesday morning unless it is raining, etc. If it is raining, the sample bucket should be changed as soon as the event ends or the following morning at 9 a.m., whichever comes first.

3. Are the rain gauge and collector checked for proper operation during the weekly site visit?

4. Is the sample visually checked for contamination (bird droppings, leaves, etc.) prior to transport to the field laboratory? Some contaminants might be seen at the site before they dissolve en route to the field laboratory.

5. Is the sample bucket enclosed in its plastic bag and shipping container prior to shipment to the field laboratory? This procedure is essential to prevent sample contamination or spillage.

Most operators were using proper collection procedures, and no instances of contamination were noted. Operators were also checking for sample contamination while at the site.

Only two site operators were unable to make a weekly equipment check. Two operators did not bag and box the bucket before transporting it to the field laboratory. In both those cases, the site was only a short walk from the field laboratory.

TABLE 9. SAMPLE COLLECTION PROCEDURES

Site Name (101)	ID	Bucket Held Only on Outside (405)	Bucket Change, 7 Days (402)	Weekly Equipment Check (403)	Contam. Check at Site (404)	Bucket Bagged/Boxed to Lab (409)
Black Belt Substn.	011000	Y	Y	Y	Y	Y
Denali NP	020390	Y	Y	Y	Y	Y
Oliver Knoll	030360	Y	Y	Y	Y	Y
Grand Canyon NP	030370	Y	Y	Y	Y	Y
Organ Pipe Cactus NM	030620	Y	Y	Y	Y	Y
Tanbark Flats	054200	Y	Y	Y	Y	Y
Hopland	054540	Y	Y	Y	Y	Y
Sequoia NP-Giant For	057550	Y	Y	Y	Y	Y
Montague	057680	Y	Y	Y	Y	Y
Chuchupate RS	058501	Y	Y	Y	Y	Y
Davis	058840	Y	Y	Y	Y	Y
Yosemite NP	058850	Y	Y	Y	Y	Y
Mesa Verde NP	061530	Y	Y	Y	Y	Y
Craters of the Moon	130343	Y	Y	Y	Y	Y
Smiths Ferry	131500	Y	Y	Y	Y	Y
Perryville Battle.	180360	Y	Y	Y	Y	Y
Wye	211320	Y	Y	Y	Y	Y
Douglas Lake	230920	Y	Y	Y	Y	Y
Raco	23096J	Y	Y	Y	Y	Y
Kellogg Bio. Stn.	232660	Y	Y	Y	Y	Y
Wellston	235340	Y	Y	Y	Y	Y
Newton	251960	Y	Y	Y	Y	Y
Custer Battle. NM	270060	Y	Y	Y	Y	Y
Glacier NP Fire WS	270570	Y	Y	Y	Y	Y
Havre Exp. Stn.	270740	Y	Y	Y	Y	Y
Clancy	270760	Y	Y	Y	Y	Y
Give Out Morgan	271340	Y	Y	Y	Y	Y
Red Rock Canyon	290080	Y	Y	Y	Y	Y
Saval Ranch	290140	Y	Y	Y	Y	Y
Smith Valley	290360	Y	Y	Y	Y	Y
Lehman Caves NM	290560	Y	Y	Y	Y	Y
Gila Cliff Dwellings	320180	Y	Y	Y	Y	Y
Bandelier NM	320720	Y	Y	Y	Y	Y
Mayhill	320840	Y	Y	Y	Y	Y
Cuba	320980	Y	Y	Y	Y	Y

(continued)

TABLE 9 (cont). SAMPLE COLLECTION PROCEDURES

Site Name (101)	ID	Bucket Held Only on Outside (405)	Bucket Change, 7 Days (402)	Weekly Equipment Check (403)	Contam. Check at Site (404)	Bucket Bagged/Boxed to Lab (409)
Capulin Mountain NM	321280	Y	Y	Y	Y	Y
Piedmont Res. Stn.	343460	Y	Y	Y	Y	Y
Clinton Crops RS	343560	Y	Y	Y	Y	N
Jordan Creek	343600	Y	Y	N	Y	Y
Finley Farms	344160	Y	Y	Y	Y	N
Salt Plains NWR	370060	Y	Y	Y	Y	Y
Great Plains Ap.	371740	Y	Y	Y	Y	Y
Goodwell Res. Stn.	372920	Y	Y	Y	Y	Y
Muleshoe NWR	450250	Y	Y	Y	Y	Y
Big Bend NP - K-Bar	450425	Y	Y	N	Y	Y
Sonora	451650	Y	Y	Y	Y	Y
Guadalupe Mtns NP	452215	Y	Y	Y	Y	Y
Throckmorton	455180	Y	Y	Y	Y	Y
LBJ Natl. Grasslands	455640	Y	Y	Y	Y	Y
Bryce Canyon NP	460110	Y	Y	Y	Y	Y
Logan	460120	Y	Y	Y	Y	Y
Murphy Ridge	460820	Y	Y	Y	Y	Y
Olympic NP Hoh RS	491410	Y	Y	Y	Y	Y
Cascades NP Marble.	491940	Y	Y	Y	Y	Y
LaGrande	492180	Y	Y	Y	Y	Y
Palouse Cons. Farm	492420	Y	Y	Y	Y	Y
Yellowstone NP TF	520860	Y	Y	Y	Y	Y

FIELD LABORATORY SURVEY

Systems Check of Field Laboratory

Table 10 lists information on seven systems audit checks that were made at each field laboratory. Field laboratories had adequate space and were clean. Five sites (9%) did not have air conditioning but were in climates that may not often require it. Required records were kept, and report forms were filled out completely in all but four cases. With one exception, rain gauge charts were annotated fully with site name, date, time on, time off, etc. Because site operators now are instructed to send the rain gauge charts to CAL, several sites had no charts (or copies of charts) on hand for review. Field samples were shipped to CAL generally within two days. Proper techniques for weighing samples were followed in all instances.

pH and Conductivity Measurement Techniques

In order to make accurate and precise pH and conductivity measurements, the analyst must be familiar with the measurement equipment, follow designated calibration procedures, and use measurement techniques consistent with good laboratory practices. Field personnel were observed while making pH and conductivity measurements, and adherence to technique was noted.

Tables 11 and 12 present the results of checks considered key to good pH and conductivity measurements, respectively. In general, specified procedures were adhered to, and laboratory technique was good. Only two sites varied in pH measurement technique. One did not use (or did not have) the slope adjust to set the pH 4 buffer response. Another used an old-style electrode which touched the bottom of the test vessel. Not all sites use the inverted cell technique for measuring conductivity. This is usually because the electrode is not the type that may be inverted. Two sites had conductivity meters that corrected the readings. Thus the mathematical corrections on the report form were not used.

Each site operator rinsed the conductivity cell with sample before taking the second reading. Only one site measured the standard, deionized water, and sample in the wrong order. NADP/NTN procedure requires the measurement of deionized water after the 75-μS/cm standard and before the precipitation sample to ensure there is no carryover from the standard to the lower ionic strength rain sample. Analysis procedures were discussed with site operators whenever the need was evident.

TABLE 10, PAGE 1. SYSTEM CHECKS OF FIELD LABORATORY

Site Name (101)	ID	Space Adequate (501)	Laboratory Clean (502)	Temperature Control (503)	Proper Weighing Technique (531)
Black Belt Substn.	011000	Y	Y	Y	Y
Denali NP	020390	Y	Y	Y	Y
Oliver Knoll	030360	Y	N	N	Y
Grand Canyon NP	030370	Y	Y	Y	Y
Organ Pipe Cactus NM	030620	Y	Y	Y	Y
Tanbark Flats	054200	Y	Y	Y	Y
Hopland	054540	Y	Y	Y	Y
Sequoia NP-Giant For.	057550	Y	Y	Y	Y
Montague	057680	Y	Y	Y	Y
Chuchupate RS	058501	Y	Y	Y	Y
Davis	058840	Y	Y	Y	Y
Yosemite NP	058850	Y	Y	Y	Y
Mesa Verde NP	061530	Y	Y	Y	Y
Craters of the Moon	130343	Y	Y	N	Y
Smiths Ferry	131500	Y	Y	Y	Y
Perryville Battle.	180360	Y	Y	Y	Y
Wye	211320	Y	Y	Y	Y
Douglas Lake	230920	Y	Y	Y	Y
Raco	230980	Y	Y	Y	Y
Kellogg Bio. Stn.	232660	Y	Y	Y	Y
Wellston	235340	Y	Y	Y	Y
Newton	251960	Y	Y	Y	Y
Custer Battle. NM	270060	Y	Y	Y	Y
Glacier NP Fire WS	270570	Y	Y	Y	Y
Havre Exp. Stn.	270740	Y	Y	Y	Y
Clancy	270760	Y	Y	Y	Y
Give Out Morgan	271340	Y	Y	Y	Y
Red Rock Canyon	290080	Y	Y	Y	Y
Saval Ranch	290140	Y	Y	Y	Y
Smith Valley	290360	Y	Y	Y	Y
Lehman Caves NM	290560	Y	N	N	Y
Gila Cliff Dwellings	320180	Y	Y	N	Y
Bandelier NM	320720	Y	Y	Y	Y
Mayhill	320840	Y	Y	Y	Y
Cuba	320980	Y	Y	Y	Y

(continued)

TABLE 10, PAGE 1 (cont). SYSTEM CHECKS OF FIELD LABORATORY

Site Name (101)	ID	Space Adequate (501)	Laboratory Clean (502)	Temperature Control (503)	Proper Weighing Technique (531)
Capulin Mountain NM	321280	Y	Y	Y	Y
Piedmont Res. Stn.	343460	Y	Y	Y	Y
Clinton Crops RS	343560	Y	Y	Y	Y
Jordan Creek	343600	Y	Y	Y	Y
Finley Farms	344160	Y	Y	Y	Y
Salt Plains NWR	370060	Y	Y	Y	Y
Great Plains Ap.	371740	Y	Y	Y	Y
Goodwell Res. Stn.	372920	Y	Y	Y	Y
Muleshoe NWR	450250	^	^	^	^
Big Bend - X-Bar	450425	Y	Y	Y	Y
Sonora	451650	Y	Y	Y	Y
Guadalupe Mtns. NP	452215	Y	Y	Y	Y
Throckmorton	455180	Y	N	Y	Y
LBJ Natl. Grasslands	455640	Y	Y	Y	Y
Bryce Canyon NP	460110	Y	Y	Y	Y
Logan	460120	Y	N	Y	Y
Murphy Ridge	460820	Y	N	Y	Y
Olympic NP Hoh. RS	491410	Y	Y	Y	Y
Cascades NP Marble.	491940	Y	Y	Y	Y
LaGrande	492180	Y	Y	Y	Y
Palouse Cons. Farm	492420	Y	Y	Y	Y
Yellowstone NP TF	520860	Y	Y	N	Y

^ = not checked.

TABLE 10, PAGE 2. SYSTEM CHECKS OF FIELD LABORATORY

Site Name (101)	ID	Report Forms Complete (538)	Rain Charts Fully Annotated (542-546)	Elapsed Time Sample Removal Until Shipment (days) (533)
Black Belt Substn.	011000	Y	Y	same day
Denali NP	020390	Y	Y	1 day
Oliver Knoll	030360	Y	Y	1 day
Grand Canyon NP	030370	Y	Y	1 day
Organ Pipe Cactus NM	030620	N	Y	1 day
Tanbark Flats	054200	Y	Y	1 day
Hopland	054540	Y	Y	same day
Sequoia NP-Giant For.	057550	Y	Y	1 day
Montague	057680	Y	Y	1 day
Chuchupate RS	058501	Y	Y	1 day
Davis	058840	Y	Y	same day
Yosemite NP	058850	Y	Y	1 day
Mesa Verde NP	061530	Y	Y	1 day
Craters of the Moon	130343	Y	Y	^
Smiths Ferry	131500	Y	Y	1 day
Perryville Battle.	180360	Y	Y	next day
Wye	211320	Y	Y	2 days
Douglas Lake	230920	Y	Y	2 days
Raco	230980	Y	Y	1 day
Kellogg Bio. Stn.	232660	Y	Y	same day
Wellston	235340	Y	Y	1-2 days
Newton	251960	Y	^	1 day
Custer Battle. NM	270060	Y	Y	1 day
Glacier NP Fire WS	270570	Y	Y	1 day
Havre Exp. Stn.	270740	Y	Y	1 day
Clancy	270760	Y	Y	same day
Give Out Morgan	271340	Y	Y	^
Red Rock Canyon	290080	Y	Y	1 day
Saval Ranch	290140	Y	Y	1 day
Smith Valley	290360	Y	Y	same day
Lehman Caves NM	290560	Y	Y	1 day
Gila Cliff Dwellings	320180	Y	Y	1 day
Bandelier NM	320720	Y	Y	same day
Mayhill	320840	Y	Y	same day
Cuba	320980	Y	Y	same day

(continued)

TABLE 10, PAGE 2 (cont). SYSTEM CHECKS OF FIELD LABORATORY

Site Name (101)	ID	Report Forms Complete (538)	Rain Charts Fully Annotated (542-546)	Elapsed Time Sample Removal Until Shipment (days) (533)
Capulin Mountain NM	321280	N	Y	1 day
Piedmont Res. Stn.	343460	Y	Y	next day
Clinton Crops RS	343560	Y	N	^
Jordan Creek	343600	Y	Y	^
Finley Farms	344160	Y	^	1 day
Salt Plains NWR	370060	Y	Y	1 day
Great Plains Ap.	371740	Y	Y	1 day
Goodwell Res. Stn.	372920	N	Y	1 day
Muleshoe NWR	450250	^	^	^
Big Bend - K-Bar	450425	Y	Y	2 days
Sonora	451650	Y	Y	1 day
Guadalupe Mtns. NP	452215	Y	Y	1 day
Throckmorton	455180	Y	^	1 day
LBJ Natl. Grasslands	455640	Y	Y	1 day
Bryce Canyon NP	460110	N	Y	1 day
Logan	460120	Y	Y	1 day
Murphy Ridge	460820	Y	Y	1 day
Olympic NP Hoh. RS	491410	Y	Y	1 day
Cascades NP Marble.	491940	Y	Y	1 day
LaGrande	492180	Y	Y	1 day
Palouse Cons. Farm	492420	Y	Y	1 day
Yellowstone NP TF	520860	Y	Y	1-3 days

^ = not checked.

TABLE 11. pH MEASUREMENT TECHNIQUES

Site Name (101)	ID	Fill Hole Open (608)	Distilled Water Rinses (609,612)	Slope Adjust Used (611)	Electrode Tip Protected (613)
Black Belt Substn.	011000	Y	Y	Y	Y
Denali NP	020390	Y	Y	Y	Y
Oliver Knoll	030360	Y	Y	Y	Y
Grand Canyon NP	030370	Y	Y	Y	Y
Organ Pipe Cactus NM	030620	Y	Y	Y	Y
Tanbark Flats	054200	Y	Y	Y	Y
Hopland	054540	Y	Y	Y	Y
Sequoia NP-Giant For	057550	Y	Y	Y	Y
Montague	057680	Y	Y	Y	Y
Chuchupate RS	058501	Y	Y	Y	Y
Davis	058840	Y	Y	Y	Y
Yosemite NP	058850	Y	Y	Y	Y
Mesa Verde NP	061530	Y	Y	Y	Y
Craters of the Moon	130343	Y	Y	Y	N
Smiths Ferry	131500	Y	Y	Y	Y
Perryville Battle.	180360	Y	Y	Y	Y
Wye	211320	Y	Y	Y	Y
Douglas Lake	230920	Y	Y	Y	Y
Raco	230980	Y	Y	Y	Y
Kellogg Bio. Stn.	232660	Y	Y	N	Y
Wellston	235340	Y	Y	Y	Y
Newton	251960	Y	Y	Y	Y
Custer Battle. NM	270060	Y	Y	Y	Y
Glacier NP Fire WS	270570	Y	Y	Y	Y
Havre Exp. Stn.	270740	Y	Y	Y	Y
Clancy	270760	Y	Y	Y	Y
Give Out Morgan	271340	Y	Y	Y	Y
Red Rock Canyon	290080	Y	Y	Y	Y
Saval Ranch	290140	Y	Y	Y	Y
Smith Valley	290360	Y	Y	Y	Y
Lehman Caves NM	290560	Y	Y	Y	Y
Gila Cliff Dwellings	320180	Y	Y	Y	Y
Bandelier NM	320720	Y	Y	Y	Y
Mayhill	320840	Y	Y	Y	Y
Cuba	320980	Y	Y	Y	Y

(continued)

TABLE 11 (cont). pH MEASUREMENT TECHNIQUES

Site Name (101)	ID	Fill Hole Open (608)	Distilled Water Rinses (609,612)	Slope Adjust Used (611)	Electrode Tip Protected (613)
Capulin Mountain NM	321280	Y	Y	Y	Y
Piedmont Res. Stn.	343460	Y	Y	Y	Y
Clinton Crops RS	343560	Y	Y	Y	Y
Jordan Creek	343600	Y	Y	Y	Y
Finley Farms	344160	Y	Y	Y	Y
Salt Plains NWR	370060	Y	Y	Y	Y
Great Plains Ap.	371740	Y	Y	Y	Y
Goodwell Res. Stn.	372920	Y	Y	Y	Y
Muleshoe NWR	450250	^	^	^	^
Big Bend - K-Bar	450425	Y	Y	Y	Y
Sonora	451650	Y	Y	Y	Y
Guadalupe Mtns NP	452215	Y	Y	Y	Y
Throckmorton	455180	Y	Y	Y	Y
LBJ Natl. Grasslands	455640	Y	Y	Y	Y
Bryce Canyon NP	460110	Y	Y	Y	Y
Logan	460120	Y	Y	Y	Y
Murphy Ridge	460820	Y	Y	Y	Y
Olympic NP Hoh RS	491410	Y	Y	Y	Y
Cascades NP Marble.	491940	Y	Y	Y	Y
LaGrande	492180	Y	Y	Y	Y
Palouse Cons.	492420	Y	Y	Y	Y
Yellowstone NP TF	520860	Y	Y	Y	Y

^ = not checked.

TABLE 12. CONDUCTIVITY MEASUREMENT TECHNIQUES

Site Name (101)	ID	Inverted Cell Technique (707)	Standard Tested Before H2O (711)	Distilled Water Rinse (710)	Sample Rinse (712)	Conductivity Values Corrected (713)
Black Belt Substn.	011000	N	Y	Y	N	Y
Denali NP	020390	Y	Y	Y	Y	Y
Oliver Knoll	030360	N	Y	Y	Y	Y
Grand Canyon NP	030370	Y	Y	Y	Y	Y
Organ Pipe Cactus NM	030620	Y	Y	Y	Y	Y
Tanbark Flats	054200	Y	Y	Y	Y	Y
Hopland	054540	Y	Y	Y	Y	Y
Sequoia NP-Giant For	057550	Y	Y	Y	N	Y
Montague	057680	Y	Y	Y	Y	Y
Chuchupate RS	058501	Y	Y	Y	Y	Y
Davis	058840	N	Y	Y	Y	Y
Yosemite NP	058850	Y	Y	Y	Y	Y
Mesa Verde NP	061530	Y	Y	Y	Y	Y
Craters of the Moon	130343	Y	Y	Y	Y	Y
Smiths Ferry	131500	Y	Y	Y	Y	Y
Perryville Battle.	180360	N	Y	Y	Y	Y
Wye	211320	Y	Y	Y	Y	Y
Douglas Lake	230920	Y	Y	Y	Y	Y
Raco	230980	Y	N	Y	Y	Y
Kellogg Bio.	232660	N	Y	Y	Y	Y
Wellston	235340	^	Y	Y	^	Y
Newton	251960	Y	Y	Y	Y	Y
Custer Battle. NM	270060	Y	Y	Y	Y	Y
Glacier NP Fire WS	270570	Y	Y	Y	Y	Y
Havre Exp. Stn.	270740	Y	Y	Y	Y	Y
Clancy	270760	Y	Y	Y	Y	Y
Give Out Morgan	271340	N	Y	Y	Y	Y
Red Rock Canyon	290080	Y	Y	Y	Y	Y
Saval Ranch	290140	Y	Y	Y	Y	Y
Smith Valley	290360	Y	Y	Y	Y	Y
Lehman Caves NM	290560	Y	Y	Y	Y	Y
Gila Cliff Dwell	320180	Y	Y	Y	Y	Y
Bandelier NM	320720	Y	Y	Y	Y	Y
Mayhill	320840	^	^	^	^	^
Cuba	320980	N	Y	Y	Y	Y

(continued)

TABLE 12 (cont). CONDUCTIVITY MEASUREMENT TECHNIQUES

Site Name (101)	ID	Inverted Cell Technique (707)	Standard Tested Before H2O (711)	Distilled Water Rinse (710)	Sample Rinse (712)	Conductivity Values Corrected (713)
Capulin Mountain NM	321280	Y	Y	Y	Y	Y
Piedmont Res. Stn.	343460	N	Y	Y	N	N
Clinton Crops RS	343560	N	Y	Y	N	N
Jordan Creek	343600	Y	Y	Y	Y	Y
Finley Farms	344160	N	Y	Y	Y	Y
Salt Plains NWR	370060	Y	Y	Y	Y	Y
Great Plains Ap.	371740	Y	Y	Y	Y	Y
Goodwell Res. Stn.	372920	Y	Y	Y	Y	Y
Muleshoe NWR	450250	^	^	^	^	^
Big Bend - K-Bar	450425	Y	Y	Y	Y	Y
Sonora	451650	Y	Y	Y	Y	Y
Guadalupe Mtns NP	452215	Y	Y	Y	Y	Y
Throckmorton	455180	Y	Y	Y	Y	Y
LBJ Natl. Grasslands	455640	N	Y	Y	Y	Y
Bryce Canyon NP	460110	Y	Y	Y	Y	Y
Logan	460120	Y	Y	Y	Y	Y
Murphy Ridge	460820	Y	Y	Y	Y	Y
Olympic NP Hoh RS	491410	Y	Y	Y	Y	Y
Cascades NP Marble.	491940	N	Y	Y	Y	Y
LaGrande	492180	N	Y	Y	Y	Y
Palouse Cons. Farm	492420	Y	Y	Y	Y	Y
Yellowstone NP TF	520860	Y	Y	Y	Y	Y

^ = not checked.

Results of Field Site Analysis of Simulated Precipitation

Each field laboratory was asked to analyze a performance audit solution for conductivity and pH. These solutions were prepared by dilution of EPA-supplied performance test solutions; the audit values, designated by EPA, are about pH 4.3, and conductivity is about 20 μS/cm. Designated NADP/NTN network quality limits are ± 0.1 unit for pH and ± 4 μS/cm for conductivity. Table 13 summarizes the findings.

Fifty-two (97%) of the 55 field laboratories checked had pH results within ± 0.1 unit of the designated value. The average absolute difference was 0.05 ± 0.09 pH unit. Faulty pH electrodes were the cause of the inaccurate readings at three sites. One site had an inoperative pH electrode and could not be tested. Another site did not conduct pH measurements. One hundred percent of the 53 field laboratories obtained conductivity values which varied by no more than ± 4 μS/cm from the designated value. The average absolute difference was 1.2 ± 0.8 μS/cm.

Balances are used at the sites to weigh the mass of precipitation collected by the Aerochem Metrics collector. They are usually mechanical triple-beam balances. The balances were checked with weights having designated values ranging from approximately 800 to 4000 g.

Only one balance of 56 checked had errors of greater than 5 g over the range of test weights. In fact, more than half of the 56 balances agreed within ± 1 g of the test weights' designated values. Fifty-five of 56 balances responded within ± 5 g of the audit test weight value over the range of 823 to 4043 g. Thus if the disagreement were 5 g at a loading of 823 g, the disagreement would be only 0.6%, a small variation for the worst case. Refer to Figure 5 for the distribution of absolute differences.

TABLE 13. RESULTS OF FIELD SITE ANALYSIS OF SIMULATED PRECIPITATION

Site Name (101)	pH (pH units)			Conductivity (μS/cm)			
	Site	Audit (604)	Diff*	DI H2O (703)	Site	Audit (705)	Diff*
Black Belt Substn.	4.28	4.32	-0.04	4.8	20.9	20.5	0.40
Denali NP	4.30	4.31	-0.01	1.7	25.4	24.0	1.40
Oliver Knoll	4.31	4.31	0	6.5	26.1	24.1	2
Grand Canyon NP	4.32	4.31	0.01	1.3	24.1	24.0	0.10
Organ Pipe Cactus NM	4.33	4.31	0.02	5.3	27.0	24.1	2.90
Tanbark Flats	4.34	4.31	0.03	1.1	24.1	24.1	0
Hopland	4.35	4.31	0.04	1.9	23.9	24.1	-0.20
Sequoia NP-Giant For	4.32	4.31	0.01	1.1	26.6	24.1	2.50
Montague	4.34	4.31	0.03	1.2	24.7	24.1	0.60
Chuchupate RS	4.37	4.31	0.06	1.9	22.3	24.1	-1.80
Davis	4.24	4.31	-0.07	^	21.8	24.1	-2.30
Yosemite NP	4.32	4.31	0.01	1.3	26.0	24.1	1.90
Mesa Verde NP	4.27	4.31	-0.04	2.0	25.5	24.1	1.40
Craters of the Moon	4.35	4.32	0.03	1.3	21.8	20.5	1.30
Smiths Ferry	4.34	4.32	0.02	2.4	22.0	20.5	1.50
Perryville Battle.	4.31	4.32	-0.01	1.1	19.9	20.5	-0.60
Wye	^	^	^	1.5	19.8	20.5	-0.70
Douglas Lake	4.30	4.32	-0.02	1.0	21.2	20.5	0.70
Raco	4.32	4.32	0	1.5	21.7	20.5	1.20
Kellogg Bio. Stn.	3.71	4.32	-0.61	9.7	18.4	20.5	-2.10
Wellston	4.29	4.32	-0.03	2.8	18.5	20.5	-2
Newton	4.32	4.31	0.01	10.1	24.0	24.1	-0.10
Custer Battle. NM	4.28	4.32	-0.04	1.8	23.9	22.5	1.40
Glacier NP Fire WS	4.38	4.32	0.06	3.7	21.9	20.5	1.40
Havre Exp. Stn.	4.28	4.32	-0.04	1.2	20.7	20.5	0.20
Clancy	4.33	4.32	0.01	1.6	21.2	20.5	0.70
Give Out Morgan	4.60	4.31	0.29	^	^	^	^
Red Rock Canyon	4.34	4.31	0.03	1.1	24.4	24.1	0.30
Saval Ranch	4.30	4.32	-0.02	1.7	21.0	20.5	0.50
Smith Valley	4.25	4.31	-0.06	2.9	24.3	24.1	0.20
Lehman Caves NM	4.35	4.32	0.03	1.9	20.9	20.5	0.40
Gila Cliff Dwellings	4.32	4.31	0.01	2.1	25.8	24.1	1.70
Bandelier NM	4.32	4.31	0.01	2.1	25.0	24.1	0.90
Mayhill	4.38	4.31	0.07	^	^	^	^
Cuba	4.38	4.31	0.07	1.8	21.9	24.1	-2.20

(continued)

TABLE 13 (cont). RESULTS OF FIELD SITE ANALYSIS OF SIMULATED PRECIPITATION

Site Name (101)	pH (pH units)			Conductivity (μS/cm)			
	Site	Audit (604)	Diff*	DI H2O (703)	Site	Audit (705)	Diff*
Capulin Mountain NM	4.28	4.31	-0.03	1.7	24.1	24.3	-0.20
Piedmont Res. Stn.	4.27	4.32	-0.05	1.9	19.7	20.5	-0.80
Clinton Crops RS	4.27	4.32	-0.05	2.1	18.5	20.5	-2
Jordan Creek	4.25	4.32	-0.07	2.0	22.2	20.5	1.70
Finley Farms	4.28	4.31	-0.03	1.7	25.4	24.1	1.30
Salt Plains NWR	4.23	4.31	-0.08	4.9	24.2	24.1	0.10
Great Plains Ap.	4.30	4.31	-0.01	1.0	23.8	24.1	-0.30
Goodwell Res. Stn.	4.34	4.31	0.03	3.98	24.1	25.9	-1.80
Muleshoe NWR	^	^	^	^	^	^	^
Big Bend - K-Bar	4.23	4.31	-0.08	4.3	24.1	24.1	0
Sonora	4.34	4.31	0.03	0.8	26.9	24.1	2.80
Guadalupe Mtns NP	4.33	4.31	0.02	2.3	26.0	24.1	1.90
Throckmorton	4.32	4.31	0.01	1.6	24.7	24.1	0.60
LBJ Natl. Grasslands	4.30	4.31	-0.01	1.6	22.4	24.1	-1.70
Bryce Canyon NP	4.32	4.31	0.01	0.8	26.1	24.1	2
Logan	4.38	4.32	0.06	^	^	^	^
Murphy Ridge	4.34	4.32	0.02	1.8	21.7	20.5	1.20
Olympic NP Hoh RS	4.31	4.31	0	2.7	26.0	24.1	1.90
Cascades NP Marble.	4.18	4.31	-0.13	1.7	24.1	25.5	-1.40
LaGrande	4.34	4.31	0.03	4.2	26.8	24.1	2.70
Palouse Cons.	4.32	4.31	0.01	1.0	25.6	24.1	1.50
Yellowstone NP TF	4.32	4.32	0	2.9	21.8	20.5	1.30

* Difference = Site Value - Audit Value
^ = not checked.

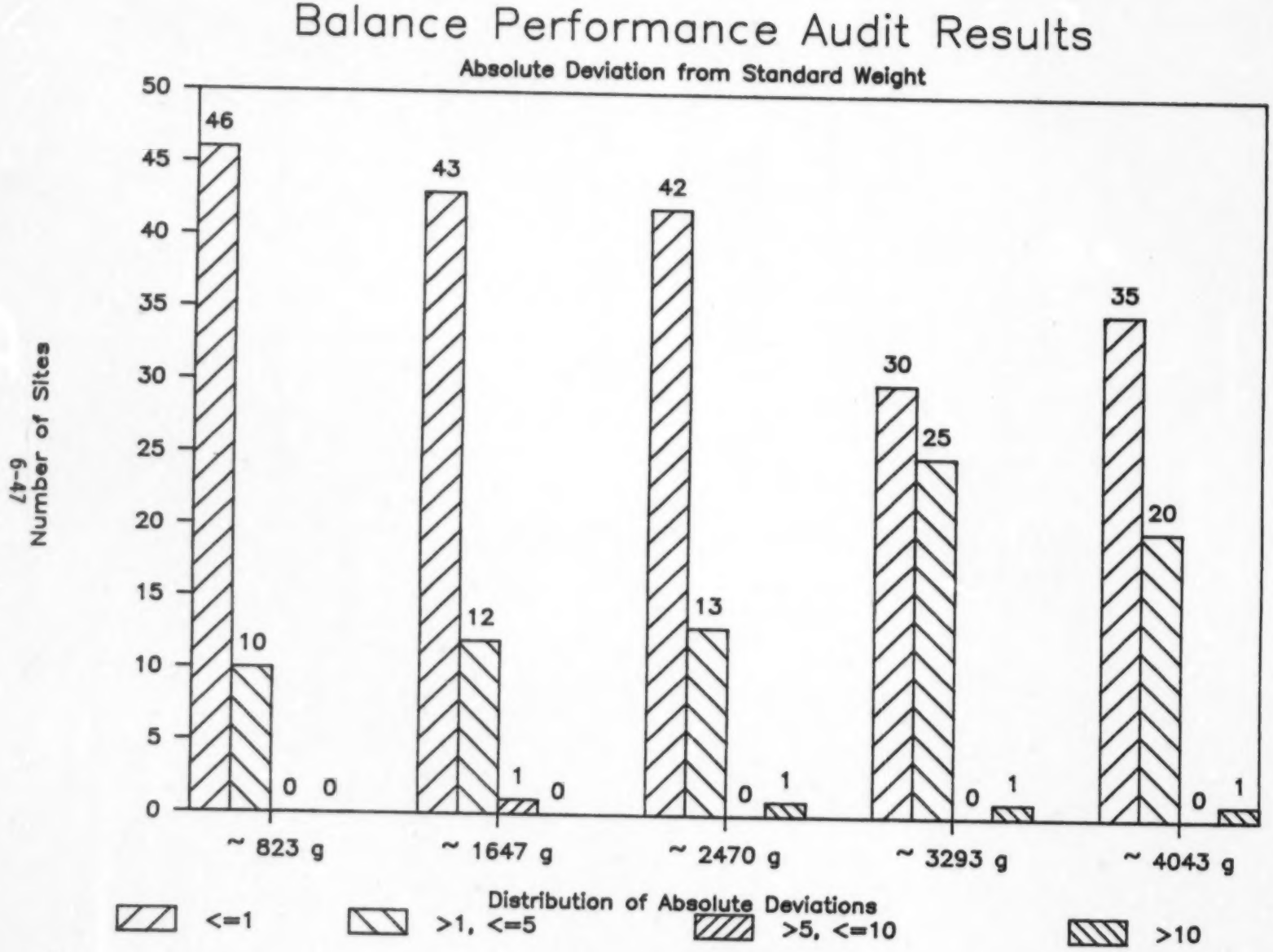


Figure 5. Balance Performance Audit Results

SECTION 7
COMPARISON OF 1988 AND 1985-1986 SITE VISITATION RESULTS

In order to assess changes in network siting and operations, selected results from visits to 55 NADP/NTN sites made in year two (1988) of the second round of the site visitation program were compared to results for the same categories for the same sites from the first round (1985-1986). (Note that two new sites were visited in 1988 that were not on-line during the first round of visits.) Results from the following categories are compared: supervisory and operator personnel, siting criteria, performance of the Aerochem Metrics collector and Belfort rain gauge, and results of field determinations of pH andconductivity.

SITE SUPERVISOR AND OPERATOR CHANGES

It was noted that twenty-one of fifty-five supervisors (38%) had been reassigned since the first visits. Also, 29 of fifty-five operators (50%) had changed. Three of the operators had become supervisors, so continuity was not lost in these instances.

SITING CRITERIA COMPARISONS

Table 14 lists three siting criteria relating to precipitation collector placement and six criteria relating to site surroundings. In almost every case, there was an improvement in the number of sites meeting the criteria.

Wet bucket orientation

In the first round, collectors at 13 of 55 sites checked did not have the wet bucket oriented toward the West, as is specified by siting criteria. In the second round, seven of these 13 were found to have been corrected; six remained uncorrected (Blackbelt, Denali, Perryville, Red Rock Canyon, Smith Valley, and LaGrande). One site, Olympic NP, which was correct in Round 1, was found to face NW in Round 2.

TABLE 14. COMPARISON OF RESULTS OF SITING CRITERIA: ROUND 1 AND ROUND 2 VISITS

Siting Criteria	Number and Percent Not Meeting Criteria*		Nonstandard Sites**
	Round 1	Round 2	Round 1 / Round 2
Collector Location			
• Wet bucket orientation	13 (24%)	7 (13%)	13 / 6
• Collector-gauge separation	18 (33%)	15 (27%)	18 / 13
• Collector-gauge heights	7 (13%)	5 (9%)	7 / 3
Site Surroundings			
• Vegetation greater than 2 feet in height within 30 m	13 (24%)	15 (27%)	13 / 5
• 45° angle violation from tree or obstruction	6 (8%)	5 (9%)	6 / 3
• Storage or parking lots < 100 m	6 (11%)	6 (11%)	6 / 2
• Animals < 30 m	9 (16%)	12 (22%)	9 / 6
• Feedlots < 500 m	15 (27%)	3 (5%)	15 / 2
• Transit sources < 100 m	2 (4%)	2 (4%)	2 / 0

* Includes only those 55 sites visited in Round 2 that were also visited in Round 1.

** Compares number of nonstandard sites in Round 1 to the same sites in Round 2. For example, of the 13 sites that were nonstandard in Round 1 with respect to wet bucket orientation, 6 were also nonstandard at the time of Round 2 visits.

Collector-Gauge Separation

In Round 1, 18 of 53 sites checked did not satisfy the criterion for proper collector-gauge separation of at least 5 m but less than 30 m. In all 18 cases the separation was less than 5 m. In Round 2, it was found that collector and gauge at five of these 18 sites were now properly separated; equipment at two other sites had been separated further, but not quite by the prescribed 5m; and equipment at one site, Gila Cliff Dwellings, had been moved from a proper separation of 5 m to an out-of-tolerance 3 m! For the two sites not originally checked in Round 1, Smiths Ferry was adequately separated and Perryville was not. Separations of 3 m or less were noted at the following sites during the Round 2 visits: Blackbelt, Denali, Grand Canyon, Red Rock Canyon, Smith Valley, Gila Cliff Dwellings, Cuba, and Yellowstone NP.

Collector-Gauge Heights

The heights of the inlets of the collector and gauge should be within 12 in. of each other. In Round 1, seven sites did not meet his criterion. In Round 2, four of these seven were judged to be acceptable. However, two sites which had been acceptable in Round 1 were slightly out of tolerance in Round 2 (Gila Cliff Dwellings and Capulin Mt. NM). In each case the gauge orifice was from 13.5 to 15 in. lower than the collector's bucket rim. This is considered a minor variation.

Vegetation Growth within 30 m of Collector

Criteria call for the height of natural vegetation (grasses, shrubs, etc.) to be kept to 2 ft or less within a 30-m radius of the collector. In Round 1, 13 sites had vegetation higher than this. In Round 2, 15 sites did not meet the criteria. Because 8 of the 13 found out of tolerance in Round 1 were corrected by the time of Round 2, this means 10 additional sites had allowed vegetation to grow too high. The problem of maintaining vegetation height is a continuing one.

45° Violation from Tree or Obstruction

No structure or tree should project on the collector from greater than a 45° angle. In Round 1, 6 instances occurred among the 55 sites; in Round 2, only three of the 6 reoccurred (Sequoia, Glacier, and Olympic). Two additional sites (Great Plains and LaGrande) did not meet specifications in Round 2.

Storage or Parking Lots < 100 m from Collector

Storage buildings or stockpiles containing chemicals or agricultural supplies and vehicle parking lots should be at least 100 m removed from the collector. Six sites did not meet this criterion in Round 1; four of these were corrected by the time of Round 2 visits. Conditions at Great Plains and Olympic NP did not change. In Round 2, six sites did not meet criteria, including four sites that were acceptable in Round 1: Capulin Mountain NM, Piedmont Research Station, Finley Farms, and Muleshoe NWR.

Animals < 30 m from Collector

Animals should be kept at least 30 m away from the collector. Results show that of nine sites noted to have animals nearby during Round 1 visits, six still do. Six other sites were noted to have animals nearby. Thus in this category the number of criterion violations increased.

Feedlots < 500 m

Feedlots, dairy barns, and so on, in which large concentrations of animals are housed should be no closer than 500 m to the collector. In the first round, 15 sites were classified as being too near feedlots. In Round 2, only three sites were so classified. This represents a dramatic improvement.

Transit Sources < 100 m--

No moving sources of pollution, such as air, ground, or water traffic or the medium on which they travel (runway, road, tracks, river), should be within 100 m of the collector. In Round 1, two sites were too close to transit

sources. In Round 2, these sites were acceptable, but two other sites were found to be too close to roadways.

COLLECTOR AND RAIN GAUGE COMPARISONS

Aerochem Metrics Precipitation Collector

Six installation and operation criteria for the Aerochem Metrics collector were compared. Table 15 summarizes the findings. Three of the 57 collectors checked in 1988 were not level at the time of the Round 1 visits. All 57 were found to be level during Round 2 visits. All collectors were stably mounted, and only one had an incorrect number of counterweights at the time of Round 2 visits. Another category is clutch wear, indicated in its first stages by a shiny clutch surface or, after further wear, by a hollowed-out indent space. Eight collectors were noted to have clutch wear at the time of the Round 1 visits; 13 were seen in Round 2. However, either five of the eight clutches noted as worn in Round 1 had been repaired or conditions had been changed to minimize the wear. It is evident that corrective action steps are being taken but that clutch wear is a continuing problem, as it was noted at additional sites in Round 2. These findings are not surprising and indicate normal wear patterns as the network's equipment becomes older.

A dramatic improvement was noted in sensor performance (heating, etc.). Of the eight sensors that performed improperly at the time of Round 1 visits, all operated properly in Round 2. Sensors at two other sites were malfunctioning at the time of the Round 2 visit.

Belfort Rain Gauge

Two items concerning the rain gauge were compared. Was the gauge level, and did it require calibration by the site visitor? Table 15 lists the data. Two of fifty-five gauges common to Rounds 1 and 2 were found to be out-of-level at the time of the Round 1 visits. Both these were level at the time of the Round 2 visit. In Round 2, two others of the original 55 were judged to be out-of-level.

Rain gauges are calibrated by the site visitor if the response to known weights differs by more than ± 0.1 in. of rain.

TABLE 15. COMPARISON OF AEROCHEM METRICS COLLECTOR AND BELFORT RAIN GAUGE INSTALLATION AND PERFORMANCE: ROUND 1 AND ROUND 2 VISITS

Criteria	Number and Percent Not Meeting Criteria		Nonstandard Sites*
	Round 1	Round 2	Round 1 / Round 2
Aerochem Metrics Collector			
• Collector level	3 (5%)	0 (0%)	3 / 0
• Collector stable	1 (2%)	0 (0%)	1 / 0
• Correct counterweight	1 (2%)	1 (2%)	1 / 0
• Clutch wear	8 (14%)	13 (23%)	8 / 3
• No gaps, bucket to lid seal	0 (0%)	0 (0%)	0 / 0
• Sensor performance	8 (15%)	2 (4%)	8 / 0
Belfort Rain Gauge			
• Gauge level	2 (4%)	2 (4%)	2 / 0
• Gauge required calibration by RTI	32 (58%)	22 (41%)	32 / 19

* Of 55 collectors that were in operation at the time of both Round 1 and Round 2 visits.

Thirty-two of 55 gauges required calibration during Round 1 visits. Nineteen of these same 32 also required calibration during Round 2, but 13 did not. Nineteen gauges were found to be in calibration over the full 12-in. range during Round 1 visits. Of these 19, 13 still met calibration specifications at the time of Round 2 visits, approximately two years later. In the depth range of 0 to 5 in., gauge calibration was within ± 0.1 in. of the designated value for 45 of 54 (83%) gauges checked in Round 1. Of these 45, 37 were found to be in acceptable calibration for the depth range 0 to 5 in. at the time of the Round 2 visits.

CONDUCTIVITY AND pH MEASUREMENT COMPARISON

The sites were compared for accuracy of measurement of conductivity and pH. An improvement was noted in the number of sites that were able to determine the conductivity of a simulated precipitation sample to within $\pm$ 4 μS/cm and pH to within $\pm$ 0.1 pH unit of the designated value. Of 51 sites checked in Round 1 (that were also checked in Round 2), six had readings more than ± 0.1 pH unit from the designated value. In Round 2, three of these 51 sites had pH readings outside the tolerance limit. None of the six sites out of tolerance in Round 1 were so at the time of Round 2 visits. Of 51 sites, four exceeded the limit of ± 4 μS/cm agreement with the audit standard in Round 1. None of the 51 exceeded this limit during Round 2 visits. Two new sites (Newton and Murphy Ridge), first visited during Round 2, gave satisfactory results for pH and conductivity measurements.

SECTION 8

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